ONTARIO

THE SAFETY OF ONTARIO'S NUCLEAR REACTORS

FINAL REPORT

SELECT COMMITTEE ON
ONTARIO HYDRO AFFAIRS

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SELECT COMMITTEE ON ONTARIO HYDRO AFFAIRS

FINAL REPORT ON THE SAFETY OF ONTARIO'S NUCLEAR REACTORS

THE LEGISLATIVE ASSEMBLY OF ONTARIO
THIRD AND FOURTH SESSION: THIRTY-FIRST PARLIAMENT

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ONTARIO HYDRO AFFAIRS

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ONTARIO NUCLEAR REACTORS

THE LEGISLATIVE ASSEMBLY OF ONTARIO
THIRD AND FOURTH SESSION: THIRTY-FIRST
PARLIAMENT

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TO: THE HONOURABLE JOHN E. STOKES
Speaker of the Legislative Assembly of the Province of Ontario

Sir:

We, the undersigned members of the Committee appointed by the Legislative Assembly of the Province of Ontario on November 24, 1977* to inquire into various matters relating to Ontario Hydro, have the honour to submit the attached, final report on The Safety of Ontario's Nuclear Reactors.

Donald C. MacDonald, M.P.P.
York South
Chairman

Jim Foulds, M.P.P.
Port Arthur
Vice Chairman

George Ashe, M.P.P. Durham West	J. Albert Belanger, M.P.P. Prescott-Russell	Sean G. Conway, M.P.P. Renfrew North
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Bob Mackenzie, M.P.P. Hamilton East	Julian Reed, M.P.P. Halton-Burlington	John Williams, M.P.P. Oriole

* - Mr. Cureatz replaced Mr. McNeil on April 17, 1979;
Mr. Conway replaced Mr. Kerrio on May 31, 1979;
Mr. Kerrio replaced Mr. Nixon on December 20, 1979;
Mr. Mackenzie replaced Mr. Di Santo on June 19, 1979.

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INTRODUCTION

INTRODUCTION

The Select Committee on Ontario Hydro Affairs was established by the Legislative Assembly of the Province of Ontario on November 24, 1977 with Mr. Donald C. MacDonald, M.P.P. (York South) as Chairman, to examine and report on several matters relating to the activities of Ontario Hydro. The Committee's complete terms of reference are Appendix A to this report.

In March, 1978, the Committee tabled with the Legislature its report on Ontario Hydro's proposed uranium contracts with both Denison and Preston Mines. In October, 1978, it tabled its report on the construction of the heavy water plants at the Bruce nuclear site. During November, 1978, the Committee submitted an interim report dealing with Ontario's future commitment to nuclear power. This report contains the Committee's conclusions and recommendations on one aspect of its examination of Ontario's nuclear commitment, the safety of Ontario's nuclear reactors. Another report on a second aspect of the nuclear commitment, the final disposal of nuclear fuel wastes is also being submitted this month. Later this year, the Committee will investigate a third aspect, safety in the mining, milling and refining of uranium.

Throughout the reactor safety hearings, the Committee was aware of the motion passed by the Legislative Assembly on June 14, 1979, specifically directing it to consider "....the concerns expressed with respect to Rolphton (NPD) ...." Specific safety-related concerns about the small, demonstration reactor near Rolphton had first been raised before the Committee by a group of local citizens, banded together as the Renfrew County Citizens for Nuclear Responsibility. In order to meet the special directions of the Legislature, the Committee toured the facility, conducted a well publicized, open Committee session in the nearby community of Deep River and heard, on several separate occasions, both the detailed allegations of the citizens group and the responses of the plant operator - Ontario Hydro, the plant owner - Atomic Energy of Canada Limited (AECL) and the regulator - the Atomic Energy Control Board (AECB).

The Committee considered that its major task was to determine whether the people of Ontario should continue to accept the risks involved in the operation of nuclear reactors. Essentially this involved consideration of the likelihood that a significant proportion of the extremely large quantities of radioactivity contained in the reactor core could be released under accident conditions. A major release of this radioactivity into the atmosphere would almost immediately result in deaths and injuries from direct radiation to persons near the faulty reactor; the development of disease, some fatal, over the longer term; and the contamination of the surrounding area to an extent which would render it unuseable for some period of time.

The Committee learned that it is impossible to assure absolute safety in the operation of Ontario's nuclear reactors. There are a broad range of possible accidents and subsequent consequences with varying likelihoods of occurrence. While the design, construction and operation of Ontario's nuclear reactors is permeated with attention to safety, all possibilities cannot be foreseen or totally eliminated. Even so, given the clear commitment of Ontario Hydro and AECL to safety, the past safety record of the existing reactors and the design mechanisms

to limit the consequences of possible accidents, the Committee found that the chance of a very serious accident occurring in any single reactor is extremely small and, on the basis of the information considered to date, that the reactors are, therefore, 'acceptably safe'. In so doing, the Committee recognized fully that it was making a political/societal judgement that the benefits derived from nuclear reactors are worth the risks incurred.

In order to complete its examination of the Provincial nuclear commitment, the Committee intends to inquire fully into all facets of the nuclear cycle from the mining of uranium ore through to the disposal of radioactive waste and to consider all aspects of the nuclear industry. Only at the conclusion of its continuing investigation will the Committee be able to arrive at a broad overall finding on the appropriateness of Ontario's commitment to nuclear power.

Prior to its intensive examination of reactor safety, the Committee conducted a preliminary examination of the management of nuclear waste during seven days of hearings in October, 1978. As well, in May, 1979, the Committee briefly touched upon Ontario's contingency planning in light of the confusion evident in implementing contingency plans in the area of Harrisburg, Pennsylvania after the accident at the Three Mile Island nuclear station. Finally, the Committee has received the major findings on nuclear power of the Royal Commission on Electric Power Planning in the form of an interim report on nuclear power in Ontario entitled A Race Against Time and a Final Report on all aspects of electric power planning.

The Committee's continuing investigation will involve careful consideration of the health, environmental, safety and economic aspects of:

* mining and milling of uranium ore and disposal of mill tailings;
* refining of uranium and its fabrication into pellets and, disposal of waste products from refining;
* Ontario Hydro's particular strategy for adopting large multi-unit stations; and
* nuclear power in relation to other alternative energy sources.

Under the circumstances outlined above, it is evident that this report is not intended, and should not be viewed as, a complete response to the Committee's very broad undertaking. Rather it is a report to the Legislative Assembly on only one component, albeit an extremely important one, of the provincial nuclear commitment. A second report on the final disposal of nuclear fuel wastes, a second component of the commitment, has recently been finalized. Mining, milling, refining and fabricating will be investigated in the Committee's next set of hearings.

The report itself is set out in three chapters. Chapter 1 will outline the hearing format adopted by the Committee and the emphasis placed on ensuring full public disclosure of all information deemed relevant to the decision-making process. Chapter 2 will concentrate on the safety of Ontario's nuclear reactors outlining how the reactors operate, the risks they present, and the systems designed to reduce those risks before setting out the Committee's reasons for concluding that the reactors should be considered acceptably safe. Chapter 3 will deal with the process for regulating nuclear safety, explaining the Committee's views of both its strengths and weaknesses, leading to a series of recommended changes.

CHAPTER 1

THE FIRST FULLY PUBLIC HEARING

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The sixteen weeks of the hearings into the safety of Ontario's nuclear reactors stretched over a full calendar year including: two weeks in April, 1979 in the wake of the serious accident at the Three Mile Island nuclear power plant; one week in May to consider several significant events that had occurred at the Bruce Generating Station; another day later in May to consider a response to alleged safety-related problems at the Nuclear Power Demonstration (NPD) Station near Rolphton; seven weeks of hearings from July 4 to August 16 and three weeks from September 18 to October 4 to consider the main issues relating to the safety of Ontario's reactors; and three weeks in February, 1980 on specific topics still outstanding at the end of 1979. The main Committee hearings were organized around five basic topics:

* safety criteria and philosophy;
* basic design concepts;
* licensing approaches
* operating history and practices; and,
* compliance and reassessment procedures.

In each area the Committee identified several key concerns and centred its examination on these particular topics. It ensured that its schedule provided ample time for the nuclear industry, its regulators, its critics and others to express opinions in every area of controversy examined. Appendix B is a chronology of the hearings and sets out the Committee's activities on a daily basis. A list of the nearly 100 witnesses who appeared during the session is included as Appendix C. Appendix D describes the 150 exhibits tabled with the Committee. The exhibits contain extensive information on Ontario reactors as well conclusions and opinions on nuclear power from around the world.

The Committee began its examination of the safety of Ontario's nuclear reactors in the knowledge that nuclear safety was already subject to extensive regulation by the Atomic Energy Control Board (AECB). The regulatory process, however, excluded, to a large extent, significant public involvement and has, to date, done little to unwrap the shroud of secrecy within which the Canadian nuclear industry appears to operate. The Committee was also aware of the lengthy review of reactor safety undertaken by the Royal Commission on Electric Power Planning. The Commission's Interim Report on Nuclear Power in Ontario was available to the Committee before its reactor safety hearings began and the Final Report was available before the Committee had settled on its own conclusions and recommendations. The Chairman, Dr. Arthur Porter, and his staff opened the hearings with a two day discussion of Ontario's nuclear reactors. Unlike the regulatory process, the work of the Royal Commission involved the public to the greatest extent possible. The Committee shared the view of the Royal Commission that "....if an informed and reasonably sophisticated public involvement in the energy debate is to be achieved, then greater and freer public access to information is essential. This is particularly important in the case of nuclear power...."[1] The Committee noted, however, that the Royal Commission hearings

1. A Race Against Time, p. 65; Interim Report on Nuclear Power in Ontario, Royal Commission on Electric Power Planning, September, 1978

themselves did not result in significantly increasing the availability of information historically treated as "confidential" by both the nuclear industry and the AECB. After carefully weighing the balance between the benefits of providing greater public access to information and any possible negative safety or commercial impact which could result from the release of previously unavailable documentation, the Committee requested and received from Ontario Hydro, for its examination and public scrutiny, an enormous amount of information -- much of it never made public before. A great deal of this previously unreleased information, such as the significant event reports and correspondence between Ontario Hydro and the AECB, proved invaluable to the Committee in helping it arrive at its conclusions. Appendix E lists the 436 volumes made available in the Legislative Library and the Ontario Hydro Public Reference Centre. For security reasons and to protect commercial interests 220 volumes were controlled in the sense that reader identification is obtained and machine duplication of pages is not allowed.

The Committee also requested of AECL the release of certain documents which the Committee felt were relevant to its deliberations. In spite of some possible jurisdictional disputes, this documentation was provided voluntarily by AECL. AECL released the documentation after consultation with both the Department of Justice and the Atomic Energy Control Board. AECL made it clear, however, that the documents were being made available without constituting a precedent for other requests by this or any other provincial committee. Appendix F lists the four volumes provided by AECL.

The Committee believes strongly that freer public access to previously unavailable documentation is an essential element in the ongoing process of informing and involving the public in the nuclear debate. All the evidence heard by the Committee and on which it reached its conclusions was, and still is, available to the public at the Legislative Library and the Ontario Hydro Public Reference Centre. That information should be regularly updated and kept current. The Committee also believes that Members of the Legislative Assembly must be immediately informed of any decision, occurrence or design reanalysis, which might be of particular interest or concern to the public.

RECOMMENDATION I ONTARIO HYDRO SHOULD CONTINUE TO PROVIDE PUBLIC ACCESS TO ALL OF THE INFORMATION MADE AVAILABLE TO THE COMMITTEE BY KEEPING THE REPORTS NOW AVAILABLE IN THE LEGISLATIVE LIBRARY REGULARLY UPDATED AND CURRENT.

RECOMMENDATION II ONTARIO HYDRO SHOULD IMMEDIATELY ADVISE THE LEGISLATIVE ASSEMBLY, THROUGH THE MINISTER OF ENERGY, OF ANY DECISION, OCCURRENCE OR DESIGN REANALYSIS WHICH MIGHT BE OF PARTICULAR INTEREST OR CONCERN TO THE PUBLIC.

CHAPTER 2

THE SAFETY OF ONTARIO'S NUCLEAR REACTORS

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The major task of the Committee was to determine for itself whether the nuclear reactors operated in Ontario by Ontario Hydro are 'acceptably safe' and report its conclusion to the Legislative Assembly and the people of Ontario. This task was part of the Committee's original terms of reference, was made explicit for the station near Rolphton, and was, in the wake of the accident at Three Mile Island, a task the public expected that this Committee would undertake.

This chapter will set out very simply the basic functioning of Ontario's nuclear reactors, the risks they present and the systems designed to reduce the risks. It then goes on to set out four reasons for concluding that the reactors are "acceptably safe",* the areas where Hydro must show some improvement and the Committee's response to its special reference on the station at Rolphton. Before getting into any of these details, however, the concept of 'safety' is discussed.

The Committee would like to be able to say, simply and directly.... 'Ontario's reactors are safe', or .... 'Ontario's reactors are not safe'. It would be desirable to be able to say to the public .... 'A catastrophic nuclear accident at an Ontario reactor is impossible'. Direct, simple statements cannot be made. It is not possible to say that a nuclear reactor is absolutely safe; there are risks associated with nuclear power. It is not right to say that a catastrophic accident is impossible; there is always some chance that the worst can happen.

In a situation where absolutes are misleading, the Committee is forced to make relative judgements. If there is some chance of a catastrophic accident, that chance must be suitably small. If it is not possible to say that Ontario's reactors are absolutely safe, then they must, if allowed to operate, be judged 'acceptably safe' for continued operation. There must be a political/societal judgement that the risks from a nuclear reactor are worth its benefits -- competitively-priced, Ontario-based energy from power generating stations that are relatively non-polluting in normal operation.

Although this is a difficult judgement to make, society has always made judgements of this type. For example, motor vehicles are widely accepted in our society despite the fact that in Ontario alone about 2,000 people are killed and many more injured every year in accidents involving motor vehicles. Although few would deny that we should continue to try to make motor vehicles safer, motor vehicles are accepted as they are today. They are 'acceptably safe'.

The risks from nuclear power are much different from those involving motor vehicles. Although there are potential risks in the routine operation of nuclear reactors from the production and release of various radioactive materials, it is the threat of catastrophic accidents that is of concern to most people. The worst possible accident involving a nuclear reactor, such as the accident scenarios identified in studies of U.S. reactors, could involve the spread of radioactive poisons over large areas, killing thousands immediately, killing others through increasing susceptibility to cancer, risking genetic defects that could affect future generations and possibly contaminating large land areas for further habitation or cultivation.

*See dissent of Members Foulds, Gigantes and Mackenzie

The nuclear industry and its regulator recognize the potential danger of atomic energy and have taken elaborate precautions to ensure that dangers are minimized as far as is considered reasonable. A key element in determining what is 'reasonable' is the technical concept of risk. To a layman, 'risk' is a relative term: a risky operation would be one in which there is a high probability of an undesirable outcome. In the scientific community, risk is a precise term, defined mathematically as probability times consequence: probability being the chance of some kind of accident happening and consequence the effect on individuals or property of the accident. Thus every human action involves risk, even if the risk is something as improbable as colliding with a falling meteorite. The NPD station, for example, was licensed on the basis that the total risk to human life would never be greater than 1 chance in 100 that one person might die in any year from the operation of the plant. The scientific assessment of that level of risk (risk = probability x consequence) would equate that 1 chance in 100 for one person to a one in one thousand chance that 10 might die, a one in ten thousand chance that 100 might die, or a one in one million chance that 10,000 might die. Scientifically defined, the risk is constant.

The scientific concept of risk underlies the Canadian and international approaches to nuclear safety. Thus the industry response to a potential accident of very high consequence is to design equipment and procedures that make it increasingly improbable. The earliest commercial reactor (NPD) was licensed on the basis of constant risk (i.e. the designer always tried to equate the risk of any accident -- of high or low consequence -- to the average of one chance in 100 of killing one person). In the later reactors, the concept of diminishing risk was introduced recognizing that people are more concerned about larger accidents than smaller ones. Thus the scientifically defined risk of the accident of higher consequence must be lower than the scientifically defined risk of the accident of lower consequences. The plant designer achieves this by changing the safety systems or equipment either to reduce the consequence of the larger accident or to make it more improbable.

The Committee understands the logic of the scientific approach and the need for designers to have specific safety targets to work toward. However, for its own evaluation of nuclear safety, the mathematical rigidity of the scientific approach was difficult to accept. The more familiar the Committee became with nuclear technology and the limitations of strict mathematical approaches, the more it realized that mathematical calculations of risk can only be a general guide. Ultimately the decision whether to consider nuclear reactors 'acceptably safe' is a subjectively judgemental one based on a large number of factors outlined in the sections below.

ONTARIO'S NUCLEAR REACTORS

All Ontario Hydro's nuclear reactors are CANDU-PHW design. (CANada Deuterium Uranium - Pressurized Heavy Water). CANDU is a totally Canadian technology, conceived by AECL, then developed, implemented and refined in conjunction with Ontario Hydro and private sector component manufacturers. Ontario Hydro's current commitments call for 22 reactors in Ontario by the early 1990s. The ten commercial reactors currently operating in Ontario are the 22 megawatt Nuclear Power Demonstration reactor near Rolphton (north of Ottawa), the 208 megawatt reactor at the Bruce Nuclear Power Development on Lake Huron at Douglas Point, four 516 megawatt reactors at Pickering, just east of Toronto, and four 750 megawatt reactors also at the Bruce Nuclear Power Development.

A 'megawatt' is the unit that is used to measure the size of an electricity generating station; a 'kilowatt hour' is the unit normally used to bill a residential customer. If a one megawatt (1,000 kilowatts) station produced electricity continuously throughout the year (8,760 hours), it would produce 8,760,000 kilowatt hours. In Ontario in 1980, Ontario Hydro expects to be called upon by its customers to produce over 102 billion kilowatt hours of electricity throughout the year and be capable of meeting a peak demand of 17,100 megawatts.

Ontario Hydro has twelve further reactors at various stages of construction. Four reactors are being built for a second station at Pickering that will come into service in stages from 1982 to 1983. Four reactors are being built for a third station at Bruce to come into service from 1983 to 1987. Another four reactors are being built at a new site near Newcastle called Darlington for planned in-service dates of 1988 to 1991. The entire Ontario nuclear program can be described in superlatives.

The stations are large:

> The planned Darlington station will be among the largest nuclear stations in the world.
>
> The Bruce complex -- 2 four-unit stations, Bruce "A" and Bruce "B", plus a one unit station, Douglas Point -- is the largest nuclear complex in the world.
>
> The Pickering complex -- 2 four-unit stations, Pickering A and Pickering B -- is the largest nuclear complex in an urban setting in the world.

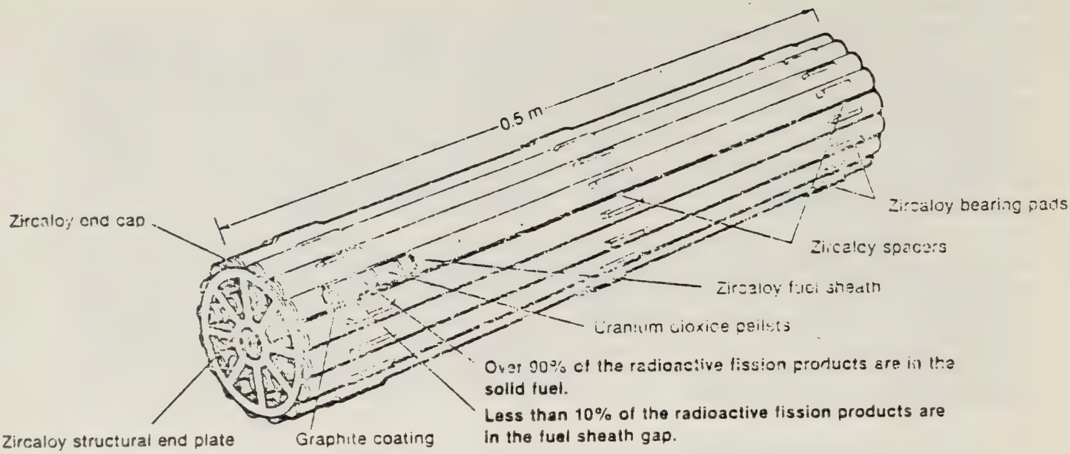
They have performed well:

> Since the Pickering A station was commissioned, one or more units have operated over 90% of the time in every year except one, making that station one of the world leaders in dependability.

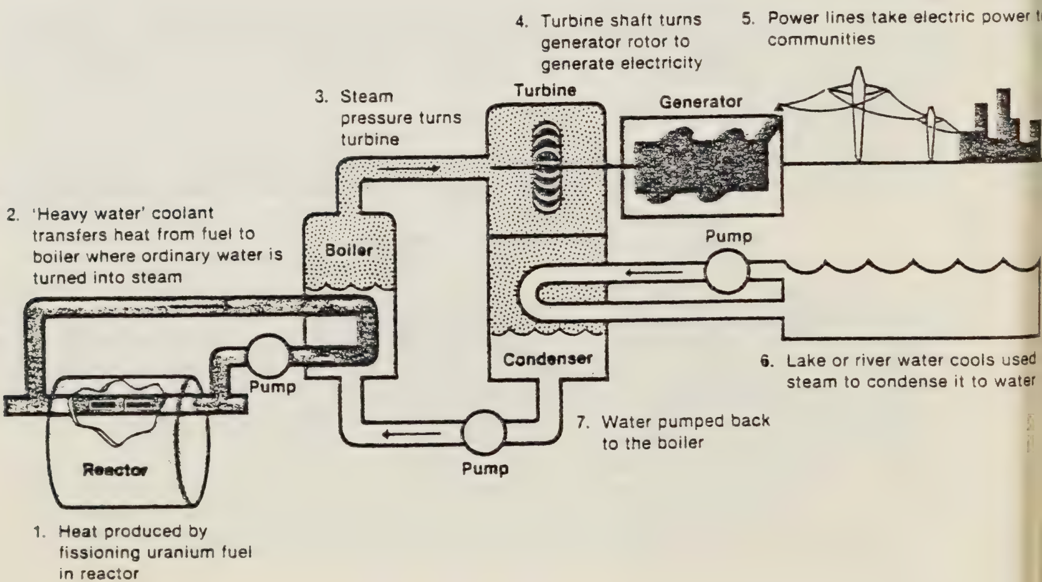
And the entire program is enormous:

> When all stations currently under construction are completed, there will be nearly 14,000 megawatts of nuclear capacity -- or theoretically enough to have met Ontario's total electric needs throughout most of the current year.

The heart of the CANDU nuclear reactor is the 'calandria' -- a large, cylindrical tank set on its side and filled with heavy water. The calandria is pierced by 300 to 500 tubes running horizontally from one end to the other. (The Douglas Point reactor has 306 tubes, Pickering has 390 tubes, and Bruce has 480). Inside the calandria tubes and separated from them by an inert gas are the pressure tubes. Uranium, in the form of ceramic uranium dioxide pellets is sealed into small tubes made of 'Zircaloy', an alloy of zirconium.



The tubes containing the fuel are assembled into a bundle, and the fuel bundle is placed inside the pressure tubes. (Douglas Point fuel bundles have 19 tubes, Pickering bundles have 28, and Bruce bundles have 37). When all the elements -- the uranium, the heavy water and various regulating and control mechanisms -- are in the right position, some of the uranium atoms begin to "fission" or break apart. As the uranium atoms fission, heat is produced. Heavy water, at high pressure, is pumped through the pressure tubes to remove the heat and use it to produce steam in a completely separate circuit of ordinary water that turns a turbine to produce electricity. The simple chart below shows the basic CANDU process.



The amount of heat produced in this almost mysterious breaking apart of the uranium atom is enormous. The heavy water passes 20 feet through the calandria in one second and rises 50 C degrees. One fuel bundle contains as much heat energy as 500 tons or about 12 train car loads of coal. The continuous circulation of heavy water keeps the temperature of the pressure tubes at about 300 C degrees or well below the point at which the fuel might melt (2800 C degrees), the Zircaloy fuel bundle might melt (1700 C degrees) or the fuel bundle might be seriously weakened (1000 C degrees). Among the most serious safety concerns is the suppression or loss of flow of coolant due to a burst pipe. If active fuel is not cooled by one of the normal process systems or emergency systems, the fuel will melt and release its radioactivity into the reactor building. CANDU reactors have a number of safety systems designed to keep the fuel from approaching dangerously high temperatures.

As soon as sensors located throughout the reactor detect any sign of a safety problem with the reactor, special systems act to shut down the machine. At Pickering and Bruce, shutdown is achieved by dropping 'shut down rods' into the reactor, and either dumping the heavy water moderator in the calandria (Pickering) or injecting a chemical "poison" into it (Bruce). Although the shutdown mechanisms act quickly to reduce reactor power, the nature of the fission reactor is such that heat continues to be produced by the fuel for many hours after the reactor is shut down. The amount of heat produced from the continuing decay of the fuel reduces very quickly to a small percentage of its full power -- in one minute it falls to 4% of full power --then, gradually, over many hours, the decay process slows to a negligible level. Three hours after shutdown the power level will have fallen to 1%. This gradually declining decay heat, while small in relation to the full power produced under normal conditions, is still very significant. Cooling must be maintained for months after a shutdown before the decay heat becomes insignificant enough that it can be removed by the air surrounding the fuel. Thus, all CANDU reactors have emergency cooling systems to provide continuous cooling if an accident disrupts the normal cooling system.

There are also many systems and design features in a CANDU reactor to prevent poisonous radioactive gases from reaching the public in significant concentrations. Among the most important are what are referred to as the multiple barriers of defence -- the five barriers between the radioactive poisons in the fuel and the public. These are:

(i) The fuel itself;
(ii) The sheathing in the fuel bundle;
(iii) The heat transport system and calandria;
(iv) The containment structures; and
(v) The exclusion zone.

Each is described briefly below:

(i) The uranium dioxide (UO_2) fuel is the first barrier to the release of fission products. UO_2 is a ceramic with a high melting point and is chemically inactive in water. Most of the radioactive fission products are permanently retained in the ceramic pellet at operating temperatures, and a small fraction (up to 10%) of the gaseous fission products are released into the gases within the tubes.

(ii) Each fuel element is sheathed with Zircaloy which forms the second barrier to fission product release. The sheath is designed to withstand the stresses resulting from UO_2 expansion and fission gas pressures, external hydraulic pressures and the mechanical loads imposed by fuel handling as well as the stresses caused by small accidents.

(iii) The coolant is contained in a closed heat transport system which forms the third barrier to fission product release. All the high-pressure piping is designed with a safety factor between the working and ultimate stresses. In most conceivable accidents, this piping must fail before fission products in the coolant are released to the containment system. In addition, the pressure tubes are inside calandria tubes which are normally kept at about 150 F degrees by the relatively cool heavy water moderator that is cooled by a separate system, and held inside the stainless steel calandria vessel that is, itself, surrounded by a cooled shield.

(iv) The reactor and heat transport system are housed in a concrete containment system that is pierced by the piping and boiler systems necessary to produce usable energy and provide access for the safety systems and by airlocks and ventilation dampers. This safety system is the fourth barrier to fission product release. There are two basic containment systems used in Canada: the vacuum building system used on multi-unit stations, and the single-building containment system adopted for single unit stations.

(v) No residences are allowed in a zone of 3,000 feet radius from the plant. This exclusion zone is the fifth barrier. The atmospheric dilution between the plant and the boundary of this zone reduces the concentration of any fission product release from the containment system by 100 to 1000 times.

Several other features of the CANDU design are conducive to enhanced safety. The combination of natural uranium fuel and heavy water moderator has significant safety advantages. Natural uranium fuel cannot become "critical" or begin to have its atoms continuously break apart or fission without the heavy water moderator. Therefore if the heavy water in the moderator is lost through a serious leak, the heat production from the fuel will eventually cease on its own. This is not the case in enriched fuel reactors that are being used and developed around the world. In these reactors, the fuel could theoretically continue to be "critical" after a very serious accident that left a molten mass of enriched fuel on the reactor floor. In light water reactors there is even a problem of a reactor becoming 'recritical' when emergency light water is pumped into the core following an accident involving the loss of normal coolant.

Other safety features of Ontario reactors include:

* The pressure tube concept (rather than the American pressure vessel) which keeps shutoff and control mechanisms in the low pressure parts of the system where they cannot be driven out by extreme pressure accident;

* The ability of the secondary heat transport systems -- such as the boilers --to absorb up to 30 minutes of heat build-up before other action must be taken if the reactor is shut down and feedwater is still available;

* And the general features of the control systems allow reactor power to build-up slowly, but be stopped quickly.

Even with all these safety features and design concepts, it is still possible for a serious accident to take place. Among the most serious is the complete loss of cooling to the reactor caused by a break in the main heat transport piping. A major piping failure calls on the emergency coolant injection system to come into play as well as other safety features described above.

A major piping failure causes:

* an immediate surge in power due to a complex set of phenomena brought about by the cooling system depressurizing through the pipe break -- requiring the shut down systems to act quickly.

* decreased cooling of the fuel -- requiring the addition of water from the emergency coolant injection system to maintain cooling to the fuel, and

* the release of energy and radioactivity to the building via flashing coolant -- bringing the "vacuum building" into action.

In order to reduce to an acceptable level the chance that this or any other believable accident sequence will seriously harm the public, many accident sequences are carefully analyzed. The Committee pressed the expert witnesses that appeared before it to outline one of the sequences of events which, though highly improbable, is conceivable, and could lead to an accident of very severe consequence. The sequence presented is highly unlikely because it requires several, simultaneous serious failures and, since there has never been a serious accident in one of the commercial CANDU reactors, the scenario requires a number of assumptions that have never been proven. The sequence could involve:

* a pipe rupture causes a loss of coolant in the reactor. As the heat builds up, various instruments detect the changes occurring in the systems and activate control and shutdown systems to quickly bring the reactor power down,

* the pipe rupture is the worst kind and in the worst location, reducing the effectiveness of emergency cooling so that the heat build up causes the tubes that make up the fuel bundles to slump or sag and the pressure tubes to sag against the calandria tubes,

* ineffectiveness of emergency cooling and failure of the moderator cooling system allows the heat of the pressure tubes and fuel bundles to continue to rise, causing the fuel bundles to fall apart and the pressure tubes and then the calandria tubes, to sag and break,

* the broken distorted interior of the calandria is such that effective cooling cannot be brought to bear,

* as the decay heat builds up the Zircaloy tubes begin to melt. As the melting zirconium comes in contact with steam from the cooling water being poured into the reactor, small heat-producing explosions take place,

* the breaks in piping and pressure relief valves on the calandria opened by steam pressure permit radioactive steam to flash into the reactor building and thus into the entire containment system,

* the containment system fails to function properly and the radioactive gases are released to the atmosphere where poor dispersion conditions carry them in a concentrated state over a populated area.

This accident sequence would be considered, at the least, to be a "triple failure" accident:

(1) failure of the regular cooling systems including the primary heat transport system and the moderator cooling system;

(2) failure of the emergency coolant injection system; and,

(3) failure of the containment system -- compounded by the worst weather conditions.

Although there are many arguments among nuclear engineers over how hypothetical accident sequences could develop, there is no question that if all the heat sinks are lost and there are holes in containment an accident with extremely serious public consequences will result.

Ontario Hydro is required to demonstrate to the nuclear regulatory agency, the AECB, that the performance and reliability of its process systems and safety systems are very high so that the chance of a serious accident occurring is very small. Each of the safety systems must be independent of the process systems and independent of each other to the greatest extent possible. Each safety system must be tested and maintained to be shown to be available to function 99.7% of the time at Pickering and 99.9% of the time at Bruce. In the event of a dual failure -- and the worst design basis dual failure that is required to be analyzed is the worst possible failure of the process cooling system and a major impairment of containment -- the consequences of the failure must be limited. A single failure -- the cooling system pipe break -- must be accommodated within the 500 millirem to the most exposed individual normal release limit of routine activity.

This section has described the way a CANDU reactor operates, the basic safety features and a very severe accident that could happen. In the next section it will outline the four reasons that the Committee considers Ontario's reactors 'acceptably safe'.

OPERATING REACTORS ARE 'ACCEPTABLY SAFE'

The Committee concluded on the basis of evidence examined so far that the nuclear reactors operated by Ontario Hydro are 'acceptably safe'. The Committee reached this conclusion while being fully aware that there are real risks in the peaceful use of nuclear power and that absolute safety can never be totally assured. To reach the conclusion, the Committee had to satisfy itself in four areas: the effects of radiation; the safety analysis and research carried out by the industry; the basic design; and the lessons learned from examining the incidents at the station that are recorded in abnormal or significant event report.

Radiation Release Standards

The Committee found that it had to reach its own conclusion on the probable effect of radiation on human health and the appropriateness of standards currently in effect. Actual and potential radiation releases are the main health hazard in the operation of nuclear reactors (as opposed to the actual and potential fire, explosion and atmospheric pollution dangers of fossil fuel energy sources). In the normal operation of nuclear plants, workers are exposed to small radiation leaks throughout the plant and the public is exposed to very small, but continuous releases of radioactive emissions into the water and air. In the event of a serious accident, the critical health consequences will come from the effect of the radioactive gases and particles that could be released to the atmosphere. Therefore, all conclusions on whether reactors are safe enough in normal operation and any assessment of the consequences of large scale accidents depend upon the effect that radiation might have on human health.

In a general sense, the effects of radiation on human health are well known. Alpha, beta and gamma radiation penetrate tissue to varying extents, disrupting the normal cellular structure. At very high levels of exposure, say 500 rem, radiation sickness is fatal within a few days. At more moderate levels, say 25 rem, the damage is manifest in noticeably increased risk of cancers that may occur in three years or after a latency period of ten to twenty years. As well, studies with non-human organisms indicate that radiation can cause genetic disorders that affect future generations.

The biological effects of radiation are said to have been more extensively studied than those of any other toxic material. And, the handling of irradiated materials is, generally, far more careful than that of other toxics. Nevertheless, there is some controversy about the effects of radiation on human health. The main area of dispute is about the effects of very low level exposures. Most of the reliable health effects data has been collected on populations who have received very high doses -- such as the survivors of the atomic bomb explosions at Hiroshima and Nagasaki and patients who have received massive radiation treatments.

There are three schools of thought on the effects of very low levels of radiation.

* The majority of experts believe that the risks to human health decrease substantially at low levels. In addition to citing

experimental evidence on threshold limits, they reason that the human (and other organisms) have developed a repair capability to cope with the 100 to 150 millirem of background radiation every year from natural sources such as cosmic rays, radium and radon in building materials, and potassium in our bodies, as well as from man-made sources such as X-rays, colour television sets, and the fall-out from early atomic weapon tests. In the minds of many experts, it is unlikely that very slight increases over the natural background levels or exposures that fall within the normal variation in background radiation could have a noticeable effect on human health.

* A second view, accepted by most bodies responsible for setting exposure standards is that the health effects of very low levels of radiation should be considered to be directly proportional to the effects at higher levels with no safe "threshold" dose. The "linear no-threshold hypothesis" is believed by nuclear regulators to be a conservative approach for setting standards in an area of continuing uncertainty, rather than a scientifically proven hypothesis.

* A third view, held by a very small number of researchers is that the "linear no-threshold hypothesis" understates the effects of very low levels of radiation. Several studies published in recent years claim to demonstrate that health effects of accumulating radiation at very low levels might be greater than is allowed for by the "linear hypothesis".

It is very difficult to prove conclusively that any of the views is entirely correct. In fact, even those who hold the view that the low level risk may be higher than previously estimated agree that the absolute number of additional cases is very, very small and the cases are unlikely to appear for as much as twenty years after the dose is received. The problem of proving or disproving one point of view then is to find a very large group of people who have received very small doses of radiation, track their medical records for twenty to thirty years and compare them to another large group similar in all respects except for the exposure to radiation. Since about 20% of the population will ultimately contract fatal cancer for reasons having nothing to do with the operation of nuclear power plants, anyone familiar with the problems of epidemiological studies will not be surprised that there are no conclusive long-term results.

In the light of this continuing uncertainty the Committee concluded that the "linear no-threshold hypothesis" is appropriate for standard-setting. It is a standard accepted by international authorities, by North American authorities and by recent special scientific panels. The Committee was impressed, however, by the continuing attention that must be paid to questions of radiation health effects. There are suggestions that the exposure limits for workers should be related to the workers' age. Younger workers, according to one theory should have lower exposure than older workers. Another suggestion is that total exposures should be regulated — including both occupational exposures and exposures for medical or dental purposes. As well, studies that appear to show increased danger at low levels need continuous review.

The routine emissions from nuclear reactors include a number of different elements. Two were of special interest to the Committee, carbon - 14 and tritium (or hydrogen -3). In 1978, the principal airborne releases of radioactivity from Pickering A were measured at 26,000 curies of tritium, 4,100 curies of noble gases and assumed to be 1,100 curies of carbon-14. (A curie is a common unit for measuring the radioactivity from different elements.) Although all releases are of concern and require emission standards, the noble gases are of somewhat less concern because their short half-life (a few hours to a few days) ensures that they cannot accumulate in the environment.

Carbon-14 and tritium are of comparable and special concern for similar reasons. First, they each have long half-lives: 5,730 years for carbon-14 and 12.3 years for tritium. Long half-lives allow them to accumulate in the environment around a reactor and in the global biosphere. Second, they are easily incorporated into human tissue. Carbon-14 is incorporated into the carbon that comprises about 18% of total body weight, including the fatty tissue, proteins and DNA. Tritium is incorporated into all parts of the body that contain water. Thus the radiological significance of both elements is not related to their inherent toxicity, as each is a very low energy form of radiation, but to their easy incorporation in the body.

The basis for regulatory emission standards is the 'safe limits' established by the International Council for Radiological Protection (ICRP). The ICRP is an international body drawn from experts in radiology from all over the world, and including many of the leading authorities in radiological protection. Some critics claim it is a self perpetuating body drawn from the nuclear establishment with no inclination to 'rock the boat' by imposing overly tight standards. Its supporters claim that it is made up of leading scientists and medical doctors whose reputation is beyond repute and who safeguard the independence of the Commission by not allowing membership selection by political bodies.

The ICRP has a Chairman and permanent Secretariat who call the Commission together when, in their opinion, there is a need to review overall or specific standards. The ICRP have established a 'safe limit' of 500 millirem per year for the most exposed individual from a nuclear facility and 5 rem or 5,000 millirem per year for workers. (Rem is the unit used to measure the exposure of man to radiation; millirem is 1/1,000 rem). The ICRP also emphasize the "ALARA' principle which means that despite the 'safe limit', radiation doses should be kept As Low As Reasonably Achievable, economic and social factors being taken into account.

The AECB, as a matter of explicit policy, accepts the ICRP approach and specific standards. In their view it provides the most authoritative basis for setting emissions standards for radioactive products. The AECB take responsibility for the next phase of regulatory control, reviewing and approving the specific allowable levels for the various categories of radioactive releases, including air and water borne tritium, iodine, noble gases, and particulates and establishing limits for normal operations and accident conditions. The AECB require the licencee to conduct a "pathways analysis", analyzing the various pathways by which the radioactivity can reach man and determining the resultant radiation dose to the most exposed individual. On the basis of this analysis, the AECB then set derived release limits that equate curies of radioactive releases to the ICRP limit of 500 millirem to the most exposed individual.

In the routine operation of nuclear reactors, emissions can be kept considerably lower than the derived limit. Designers and operators of Hydro stations set a release target of 1% from each category of radioactive release. In most cases the targets can be met. For example, Hydro's pathways analysis shows that they could release 10,400,000 curies of airborne tritium before the most exposed individual in the public would receive a dose of 500 millirem. The release target is set at 1% of that derived limit or 104,000 curies. In 1978 the Pickering release was 26,000 curies or 1/4 of 1% of the derived limit resulting in a dose to the theoretically calculated "most exposed individual" of about 1 1/4 millirem. Dr. E. P. Radford, a Professor of Environmental Epidemiology at the University of Pittsburgh was critical of this approach when he appeared as a witness before the Committee. Dr. Radford is familiar with radiation protection as the Chairman of the National Academy of Science's Committee on the Biological Effects of Ionizing Radiation. Dr. Radford believes that regulatory authorities should set the regulatory limits at the low levels that can be achieved by careful design and operation - the 1% level - rather than accepting the potential risks implicit in the ICRP's 'safe limit'.

At this time there is no derived release limit for carbon-14 for two reasons. First, the low energy level of carbon-14 and its very low concentration principally in the carbon dioxide and carbon monoxide gases released from the stations have made it very difficult to measure accurately the actual releases. Second, it has been assumed that releases were so far below any limits that might be set that it was not necessary to specify limits and require routine monitoring and reporting on them. Ontario Hydro's Health Physics Branch recently concluded some work on measuring releases and on tracing pathways to man that could result in a dose to the most exposed individual that is somewhere between a small fraction of a millirem and 2 1/2 millirem. At that potential dose level the AECB has become more interested in carbon-14 and is now awaiting a submission from Ontario Hydro on derived release limits and operating targets.

By focussing on carbon-14 at this preliminary stage of developing a derived release limit, the Committee was able to see clearly the range of assumptions that make up a pathways analysis and the consequent uncertainty in the very specific calculations that are made. At this time the uncertainties are in:

- The actual emissions. Hydro has made theoretical calculations of the amount of carbon-14 produced in various parts of the station. Knowledge of the amount released is less certain. The carbon-14 content in vegetation surrounding the plant is not as high as it should be if the calculated releases were correct.

- The amount taken up by man. Authorities are quite certain that the only significant pathway to man is through food grown in the vicinity of the stations. Calculations of carbon-14 ingestion are based on a mix of foods of varying carbon content assumed to be grown at the plant boundary. Since different foods have different carbon content, the mix chosen for the calculation will result in widely varying doses of carbon-14. As well, assumptions have to be made of the proportion of the food that comes from the vicinity of the plant.

In addition to these admitted uncertainties, the Committee itself was concerned that neither Ontario Hydro nor AECB know enough about the propensity of carbon-14 to accumulate in the food chain and biosphere around a plant, and the rate at which it is dispersed as it moves further from the source.

Carbon-14 is not just a problem of the 'most exposed individual'. Its long half-life makes it a problem for the global environment. In 1977 a group of experts of the OECD's Nuclear Energy Agency identified four nuclides that may be of greater global than of local concern. The four are krypton -85, iodine -129, tritium and carbon-14. The half-lives of these nuclides vary from 10.8 years for krypton -85, to 12.3 years for tritium, 5,730 years for carbon-14 and 17 million years for iodine -129. Each of these elements occurs naturally in the environment as a result of the interaction of cosmic rays from the sun with the atmosphere. They are of concern in nuclear power programs because their artificial production is a significant proportion of the natural production which will result in an increase in the global inventory of each nuclide. The large-scale atmospheric testing of nuclear weapons in the '50s did, in fact, result in large increases in the global inventory. Since atmospheric testing ended, global inventories in man's immediate environment have been declining as these elements sink into the deep oceans.

As long as Canada does not reprocess its used fuel, krypton -85 and iodine -129 are of lesser importance to Canadian regulators. These nuclides remain bound up in the used fuel and will only be released in reprocessing or in a severe accident involving fuel melting. Tritium and carbon-14 are of special concern to Canada.

- In heavy water reactors, a relatively small proportion of the tritium is bound up in the fuel. Most is produced in the large quantities of heavy water moderator and coolant. Inevitably, significant amounts are released in the air and water.

- CANDU reactors produce about 20 times as much carbon-14 as light water reactors. Only a negligible amount is bound up in the fuel.

The Committee is concerned that Canada - and Ontario in particular - may have a special global responsibility for controlling carbon-14 and tritium that goes beyond consideration of local effects. Although Ontario Hydro and AECL have programs ongoing to consider ways of further reducing tritium and carbon-14 releases, there is no national or regulatory framework for guiding their implementation.

The Committee also noted that radiation protection and the appropriateness of radiation standards is a health topic of great concern to people in Ontario -- the workers in the industry and populations located near industry facilities. Legislative responsibility for nuclear safety rests with the Federal government and Ontario has deferred responsibility to the AECB.

The AECB, with its limited staff, accepts the recommendations of the ICRP. The major Canadian role in standard-setting has been to provide representatives -- and in one case the chairman -- to the ICRP from AECL. Thus, the basic Canadian regulatory standards come from a body reputed to be dominated by those the critics call the nuclear establishment -- manufacturers, utilities, regulators.

The AECB has recently established an advisory committee of experts in radiation including some people from outside the "nuclear establishment."

The Committee believes that there is an additional need to provide a body that can focus on Ontario problems, that can do so openly and with participation from the public, and that can relate directly to the federal body.

> RECOMMENDATION III A COUNCIL SHOULD BE FORMED BY THE GOVERNMENT OF ONTARIO WITH GIVEN TERMS OF REFERENCE AND REPRESENTATION FROM WITHIN AND OUTSIDE THE NUCLEAR ESTABLISHMENT TO PROVIDE AN INSTITUTIONAL FORUM FOR PUBLIC PARTICIPATION AND A FOCUS FOR CONCERNS ABOUT RADIATION PROBLEMS IN ONTARIO, TO BUILD UP ONTARIO-BASED TECHNICAL KNOWLEDGE AND TO OVERSEE AS MUCH EPIDEMIOLOGICAL WORK AS IS NECESSARY TO DECIDE WHAT THE STANDARDS SHOULD BE FOR THE HEALTH AND SAFETY OF PEOPLE IN ONTARIO.
>
> THE COUNCIL SHOULD REVIEW PARTICULAR PROBLEMS OF RADIATION ASSOCIATED WITH OPERATING OR PLANNED REACTORS, INDEPENDENT OF ONTARIO HYDRO AND THE GOVERNMENT. THE COUNCIL SHOULD WORK TOWARD THE ESTABLISHMENT OF A FEDERAL-PROVINCIAL WORKING GROUP TO CO-ORDINATE THE NATIONAL STANDARDS WITH THE WORK AND FINDINGS OF THE PROVINCIAL GROUP. THE POWERS OF THE COUNCIL SHOULD BE THAT OF MAKING INDEPENDENT AND PUBLIC RECOMMENDATIONS TO AN APPROPRIATE MINISTER.
>
> RECOMMENDATION IV ONE OF THE FIRST TASKS THE COUNCIL SHOULD TAKE ON AND GIVE HIGH PRIORITY TO IS AN INDEPENDENT REVIEW OF THE ADEQUACY OF CURRENT PROPOSED RELEASE LIMITS FOR CARBON-14 AND TRITIUM, TAKING INTO ACCOUNT BOTH LOCAL AND GLOBAL CONCERNS.

Safety Analysis & Research

The operation of the nuclear power generating stations in Ontario is the end product of a great deal of applied research and development conducted in Canada over the past thirty-five years. One of the reasons that the Committee has concluded that the reactors operated by Ontario Hydro are "acceptably safe" is that the safety analysis and research carried out both before and after the reactors are built is very impressive.

Canada's first heavy water moderated research reactor - NRX - was built at Chalk River in 1947. Extensive research with this reactor and the experience gained with it -- including the famous accident that President Carter, as a junior U.S. naval officer, helped clean up - led to the building of a second reactor - NRU - in 1957. The NRU reactor was the foundation for the development of a reactor capable of generating electricity at commercial scale. The first prototype

commercial reactor was the Nuclear Power Demonstration (NPD) reactor at Rolphton commissioned in 1962. Success with this reactor, in both safety and operational terms led to the development of the current massive nuclear program of Ontario Hydro. This program then was built upon a solid base of research, experimentation and experience with nuclear power. Many believe the development of the CANDU reactor is one of Canada's most outstanding technological achievements.

As each station is designed and built, a massive amount of analysis is completed and documented for every part of the station's operation. The shelves of documents made available to the public through this Committee constitute the most significant parts of this material. As each aspect of the analysis is completed, it is forwarded to the AECB staff. The correspondence among the AECB, AECL and Ontario Hydro in several volumes for the licensing of the Bruce A reactor which was released to the Committee, attests to the extensive scrutiny of the analysis and documentation before a reactor is licensed.

An important part of the pre-licensing analysis is the accident analysis that is carried out and documented in the Safety Report for each station. The idea of accident analysis is to assume that very serious accidents occur and then work out the consequences of the accident. The AECB has specified certain dose limits for the releases of radioactive emissions in the event of the postulated accidents.

The dose limits are set out below:

AECB Accident Condition Dose Limits

Type	Individual Dose	Population Dose
Single Failure	0.5 rem whole body	10^4 man rem whole body
	3 rem thyroid	10^4 thyroid rem
Dual Failure	25 rem whole body	10^6 man rem whole body
	250 rem thyroid	10^6 thyroid rem

A single failure means that one of the important process systems fails and the safety systems have to cool down the reactor with minimal consequences to the public. The single failure accidents analyzed in the Pickering A Safety Report are failures of the:

* Reactor regulation system
* Heat transport system (such as a pipe break)
* Secondary system (such as loss of feedwater)
* Class IV power (requiring the use of emergency power supplies)
* Fuel handling systems (leading to uncooled fuel channels)

The dual failure accidents are those in which the failure of a key process system is accompanied by a failure of one of the safety systems. Since each safety system is supposed to be available 99.7% or 99.9% of the time, the probability of a dual failure accident is considered to be sufficiently remote to justify higher release limits for dual failures. The dual failures analyzed for the Pickering A reactor are:

* Loss of the reactor regulation system and a failure of the shutdown system.

* Loss of normal cooling of the reactor core and a failure of the shutdown system.

* Loss of normal cooling and a failure of emergency cooling.

* Loss of normal cooling and a failure of the containment system.

In conducting these accident analyses, the licensee is required to analyze various ways in which the accident might occur. For example, the loss of normal coolant accident analyses include failures of pumps, or misfunctioning valves or breaks of different sizes and different types. Further, the licensee is required to make a number of conservative assumptions about what might happen at the time of the accident. For example, in the event of a pipe break it is assumed that:

* The two most critical shutdown rods are not available, making the power rise higher than it would be if all the shutdown rods worked

* None of the process systems help out, putting a greater load on the safety systems than might, in fact, be the case.

* The weather is the very worst possible for maximizing population dose, although this condition occurs less than 10% of the time.

* The individual receiving the dose is the most susceptible member of the population -- an infant somehow lying at the plant boundary.

* The pipe breaks in the worst possible way even though extensive testing indicates that tubing used in CANDU reactors will probably leak before breaking and instrumentation should detect the leak.

It should be noted though that the assumptions are considered pessimistic but credible. The licensee is not required to analyze the "incredible". For example, the analysis of failure of containment is an analysis of the failure of the various mechanical devices included in the containment system. It is not an analysis of an accident in which the containment system is somehow simply not there when it is needed. Nevertheless, the accident analysis approach to licensing does give a good deal of confidence that accident sequences such as the one at Three Mile Island can be handled by an Ontario reactor without serious public safety consequences.

Another source of confidence in the safety of Ontario reactors is that safety research continues after the reactor is built and operational, and that the results of that research — favourable and unfavourable -- are made known to the regulator. One such area the Committee examined was the update of the loss of normal cooling accident analysis. Early analysis, using the best information and techniques available, had shown that the loss of cooling accidents could be handled by the emergency cooling systems without serious consequence. The key finding at that time was that emergency cooling would be effective in assuring that the fuel sheaths -- the Zircaloy tubes in which the fuel pellets are sealed -- would not fail. If the fuel sheaths do not fail then radioactive emissions remain trapped inside the fuel bundles and do not escape into containment. Subsequent analyses found that there was a particular kind of pipe break in a particular location that is potentially more difficult to cope with than others. In fact, analyses by AECL safety researchers showed that the emergency cooling system might not be effective in preventing the failure of a significant number of fuel bundles. This analysis was made available to the AECB and led to a number of modifications being made to Ontario reactors. It is reassuring to find that the industry itself continues to probe for weak spots in its own defences.

Basic Design Features

The CANDU reactor has been called ultra high technology. Some might consider that the only way to be satisfied that a CANDU reactor is safe enough for continued operation is to examine thoroughly each and every aspect of each and every station. If that approach were taken, the only individuals capable of reaching a conclusion on the safety of the CANDU reactor would be a few of the senior designers at AECL and Hydro. This approach would effectively eliminate the public, and their representatives on this Committee and in the Legislature, from participating in the process of deciding whether nuclear reactors are acceptable in Ontario today. Therefore, this Committee, while it listened to a great deal of technical evidence on the performance of different aspects of the reactor, sought a more straightforward way of assessing the basic features of the design.

There are two aspects of the design that are important for safety: the process systems and the safety systems. The process systems must work in such a way that the public and workers are protected from unsafe levels of radiation emissions during the normal operation of the stations. Normal operation should include the regular and anticipated kinds of accidents and mistakes that do happen. The safety systems are poised to protect the public and plant workers from the consequences of more serious accidents.

The process systems include the various heat transport systems that carry heat from the core (thereby preventing the core from overheating) to produce useful electric energy, the systems for regulating and shutting down the reactor, and the numerous instrumentation and control systems that keep the reactor operating in a safe state. Since the process systems are continuously in use -- and in the case of Pickering, Douglas Point and NPD have been for several years -- the best test of process system performance is how well they have performed to date.

The Ontario public has been well protected by the operation of the process systems in conjunction with the special safety systems. Continuous monitoring of air and waterborne emissions show that, month after month, emissions are usually less than 1/100 of the required standard. Even when there was a serious spill of irradiated water from the Pickering reactor in February of this year where the momentary concentration of tritium could have been 400 times the maximum permissible level, the total tritium emissions were still only 1.43% of the monthly emission limit. Also, the irradiated water was well diluted by the time it reached the municipal water supply.

Workers at the plant -- especially mechanical maintainers -- are exposed to radiation in the normal course of their work at the plant. Dosimeters are worn by all nuclear workers to measure their levels of exposure and provide a basis for continuous monitoring. There have been incidents where workers were exposed to radiation in excess of the AECB standard, the most recent being the overexposure of two workers cleaning spilled fuel from a pressure tube at Bruce. As well, significant numbers of workers receive annual doses that approach the maximum permissible dose of 5 rems in a year. This is in sharp contrast to Hydro's ability to keep emissions to the public below 1/100th of the required standard. Clearly, Hydro's record with workers is not as good as its record with the public. On the other hand, Hydro was able to demonstrate that it has a very high level of concern for employee safety and is vigilant in maintaining high safety standards. In fact, the total exposure of all Hydro employees peaked in 1975 at 3,145 man rem when faulty pressure tubes were being replaced at Pickering and by 1978 had fallen to 1,750 man rem despite the addition of three units at Bruce. Overall then the Committee has found that Ontario's plants operate safely under 'normal' circumstances and have been able to cope with the accidents, mistakes and malfunctions that have occurred to date.

It is not as easy to make a similar general statement about the performance of safety systems. The safety systems include the emergency cooling systems, the containment systems and back-up shutdown systems. The shutdown systems have been used a few times, but the other systems have never been called upon in any of Ontario's reactors. We cannot, therefore, judge their adequacy by objective standard of performance. Instead the Committee had to find reassurance in the logic of the design concepts and the demonstrated reliability in test performance.

Several features of safety system design are reassuring:

* The defence-in-depth approach, exemplified by the multiple barriers to radiation releases that were outlined at the beginning of this chapter, is an appropriate way to handle any toxic substance.

* Several important features of the plant have 'fail-safe' characteristics, (i.e., if the component fails, it is more likely to fail in a way that is safe rather than unsafe). For example, the shutdown rods are held poised above the reactor by electromagnetic clutches. If power fails, the rods will drop and shut the reactor down, whether this is necessary or not. The computer control systems will shut the reactor down if the operating and the standby computers malfunction and is programmed to shut the reactor down if any data is received that the computer does not "understand".

* Systems are separated as far as possible to reduce the chance that faults in the process equipment can damage the protective devices and containment provisions as well.

* Redundancy is built into many systems so that if one fails, the other is able to perform the necessary function. The important sensing instruments, for example, are all triplicated. Extra pumps are provided so that several can fail without affecting safety.

* Safety systems are designed so that they can be tested while the plant is operating. Since CANDU reactors have been able to operate, in some cases, for over 90% of the year, it is important that the 'unused' safety systems be regularly tested.

If the logic of the basic design concepts for safety systems is reassuring, then it is only necessary for Hydro to show that their systems test out to the reliability levels set by the AECB (availability 99.7% or 99.9% of the time). The record here is not as clear, not as good and not as reassuring. Hydro has a complex system of assessing availability of safety systems and reporting the availability to the AECB. The reporting system and the definition of underlying data have changed over the years making outside analysis very difficult. Overall though, it appears that important safety systems do not meet the target performance levels set by the AECB.

The Committee made a special investigation of safety system reliability and the ongoing debate between the AECB and Ontario Hydro on the adequacy of Hydro's past record and current performance. The overall impression from that special investigation is mixed: on the one hand, safety systems do not meet the reliability targets set out as a licencing condition, while on the other, the reported reliability does not necessarily indicate that the systems are inoperable and both Hydro and the AECB appear to be focussing greater attention on improving reliability.

As currently reported, safety systems do not meet the availability targets set out as conditions in the operating license. In 1978 and 1979, each operating station missed its targets.

* At NPD, the Injection Water System missed the target by 26 times in 1978 and the boiler room containment system missed by 3.1 times in 1979

* At Douglas Point, the Emergency Coolant Injection System missed by 15.8 times in 1978 and 9.6 times in 1979 while the Dousing System missed one of its targets by 5 times in 1979

* At Pickering the Emergency Coolant Injection target was missed on units 2 and 4 in 1978 and units 1, 2 and 4 in 1979 while the containment system missed its target by 6 times in 1979

* At Bruce the Emergency Coolant Injection targets on units 1, 2 and 3 were missed in 1978 and in 1979 were missed by about 200 times on all four units. In 1979 Shutdown System 2 missed its target by two times

Problems in safety system reliability are not just a recent occurrence. Each of Hydro's stations has had one or more key process or safety system with chronic problems that eventually required extensive modification. The exhibit at the conclusion of this chapter shows for a selected systems that unavailability problems do appear and take several years to resolve. For example:

* When Pickering first began to operate the system for regulating power in the reactor was unreliable. A very detailed, component-by-component assessment of the system was necessary to make the modifications that eventually made the regulation system highly reliable.

* From 1962 to 1970, NPD had continuing problems with the reliability of the mechanical parts of its containment system, such as isolating dampers and dousing valves. Again, extensive modifications were made that have resulted in a decade of high reliability. Ironically, there are now indications that modifications to other parts of the station have reduced the effectiveness of the now reliable containment system.

Safety system reliability is taken very seriously by the AECB and by Ontario Hydro and AECL. An explicit condition of the operating licence is that safety systems shall be tested and maintained to substantiate and assure the reliability and effectiveness claimed in the station Safety Report. Ontario Hydro report availability statistics at least quarterly for all the major stations. AECB on-site inspectors are available to audit test procedures, frequency and results. The Committee has some concern that attention to safety system reliability may be more procedural than actual. In the light of continuing failure to meet targets, the AECB response could be seen to be primarily exhortations and strongly worded letters while tacitly accepting that the targets will always be difficult to meet.

There are though a number of factors that make the unavailability statistics less concerning than they appear on the surface to be. Two factors are important: the overstatement of the statistical measures and the continuing effort to improve.

Nuclear power station safety systems are large and complex. An Emergency Coolant Injection System is made up of hundreds of metres of pipes with valves, headers, sensing instruments and computer controls. Numerous tests of the various subsystems are carried out while the reactor is in operation to substantiate reliability claims. Maintenance procedures involve the regular checking of each part of the system. Some parts are tested and checked frequently; others less so. Out of all the tests and checks of complex systems one statistical measure of "unavailability" is recorded in Quarterly Technical Reports.

Over the years there have been many attempts to define various classes of 'unavailability' for regular reporting. These changes make it difficult to analyze station statistics over time. They are also indicative of the difficulty in reducing complexity to a few meaningful phrases. As currently defined, it appears that 'unavailability' does not mean 'inoperability'. For example:

* In the summer of 1979, a valve in the emergency cooling system at NPD was found to be not fully open - even though the instrumentation showed it to be fully open. The Station Technical Report labelled the Emergency Cooling System 'unavailable' for one-half the period over which it was presumed to have become defective. And the valve was defective. At the same time however, there is no indication that the effectiveness of emergency cooling would have been impaired by the position of the valve. The bare 'unavailability' measure understates the reliability of the system.

* At Bruce A Generating Station, the Emergency Coolant Injection System shows a chronic unreliability. In report after report, target reliability levels are not met. It turns out though that for much of the time there have been no problems with the system itself. The problem is that certain isolating valves must be closed in order to test the system. When these valves are closed, the system is 'unavailable' for immediate use. The more often the system is tested, the worse the apparent reliability of the system appears to be. Changes to the testing procedure (specifically a contemplated increase in the speed of operation of the test valve) will improve the apparent reliability of the system, even though the system itself is not changed.

Thus the unavailability information on its own would not compel the Committee to label the stations 'not safe enough' because the raw unavailability data is not directly meaningful. In the future, as the public receives safety system reliability information on a regular basis, the information must be improved.

Another reason the Committee has enough confidence to justify continuing operation at the plant is that it appears that reliability is improving . In terms of the plant hardware, station statistics show that, over time, system reliability does improve. Each station has problems in the years following start up. Over time, the problems are solved and the statistics become more encouraging. In terms of regulatory vigilance, it appears that the AECB is paying increasing attention to compliance. A recent top-level review of safety system reliability was forced on Hydro. The on-site inspection system is being strengthened and formalized. And the AECB is paying attention to the reporting problem. Finally, Ontario Hydro has taken the extremely promising initiative of creating a Nuclear Integrity Review Panel, with membership from the senior level of the Design and Operations groups of Ontario Hydro and AECL. This panel will provide a focus, at a senior level, for a more organized and thorough approach to the review of the performance of nuclear plants. As its terms of reference state, it will aim to "ensure there is adequate reliability, effectiveness, and independence of all the nuclear systems." Among the important work this panel has sponsored is a thorough examination of the lessons to be learned from the accident at Three Mile Island and a component-by-component assessment of the reliability of the Bruce safety systems.

Although the inadequacies in the availability statistics are frustrating, they do, on balance, appear to overstate the real problems of safety system reliability. And, recent action by Hydro and the AECB give some assurance that the performance of safety systems should improve. Beyond the life of this Committee,

the public should continue to be fully informed of the reliability of safety systems and the efforts of regulators and licencees. Informed vigilance will ensure that the high level of attention is maintained.

Accordingly the Committee recommends that

RECOMMENDATION V ONTARIO HYDRO SHOULD ENSURE THAT THE NUCLEAR INTEGRITY REVIEW PANEL REPORTS ANNUALLY ON ITS ACTIVITIES TO IMPROVE THE RELIABILITY, EFFECTIVENESS AND INDEPENDENCE OF NUCLEAR SYSTEMS, HIGHLIGHTING CONCLUSIONS OF COMPLETED PROJECTS AND PROBLEMS UNDER ACTIVE STUDY. SUCH A REPORT SHOULD BE MADE AVAILABLE TO THE PUBLIC FROM ONTARIO HYDRO AND AT ALL INFORMATION CENTRES AND SHOULD BE TABLED IN THE LEGISLATIVE ASSEMBLY BY THE MINISTER RESPONSIBLE FOR ONTARIO HYDRO.

RECOMMENDATION VI THE AECB IN ITS ANNUAL REPORT SHOULD REVIEW AND COMMENT ON REPORTED UNAVAILABILITY OF SYSTEMS IN NUCLEAR POWER PLANTS AND SHOULD SUMMARIZE THE ACTIVITIES OF ITS COMPLIANCE BRANCH.

Lessons From The Significant Events

One of the important contributions this Committee made to opening up the nuclear debate in Ontario and Canada was to bring into the open all the incidents of varying degrees of seriousness that have taken place in Ontario reactors. All the reports of abnormal or significant events in all Ontario Hydro reactors are now made available for public scrutiny.

Out of the hundreds of incidents that have been reported on in Ontario reactors, the Committee examined six that had been referred to it by a shift operator at the Bruce plant, and another twelve selected by Committee members and staff. Due to the complexity of nuclear reactors, each event required a significant amount of background explanation.

Several general conclusions emerged. The most important was the recognition that accidents, mistakes and malfunctions do occur in nuclear plants: equipment fails; instrumentation gives improper readings; operators and maintainers make errors and fail to follow instructions; designs are inadequate; events that are considered 'incredible' happen. It is a sobering reality, but one we must accept, that no matter how careful we are, we must expect accidents; we must anticipate the unexpected. On the other hand the incidents themselves do give some assurance that CANDU reactors are properly designed and operated. When incidents happen, the reactor does shut down safely, and there is enough redundancy that, in the incidents that have happened, the public has not been at risk. In fact, if there were no 'incidents', then we would have no basis for verifying that the reactor is able to cope with problems.

WEAKNESSES IN HUMAN PROCESSES

A good deal of the Ontario Hydro evidence concerned their programs to ensure the most effective functioning of the organizations responsible for nuclear generation, from design through to operations and maintenance. In fact, Hydro considers "competent operators" and effective systems to "detect and correct failures" to be two of their five major public safety thrusts (along with "reliable process systems", "reliable safety systems", and "multiple barriers"). It was clear from the evidence that Hydro does devote a good deal of attention to the human factors of nuclear operations. The quality and competence of Hydro's staff was apparent in the many people who appeared before the Committee as was the care and thoughtfulness that went into the back-up documentation and analysis in the information presented to the Committee and made available to the public through the Legislative Library.

Clearly the human back-up to the physical equipment is vital to the continuing safe operation of nuclear plants. It is in this area that the Committee found evidence that Hydro needs to strengthen and improve.

* The significant events often showed instances of operator or maintainer error. Seven of the twelve events singled out for special examination involved operator error as a major contributor toward initiating, prolonging or increasing the severity of the event. Of course, the twelve events singled out were not a random sample but were specifically selected to illustrate the range of problems that occur. To that extent, the raw number of operator errors may be overstated. Nevertheless, the point is irrefutable: operators do make errors.

* There is pressure of some kind on plant operators to get or keep a unit going that leads operators to take improper actions. This pressure exists despite Hydro management's assurance that no pressure is deliberately applied, despite the station manager's assurance that no pressure should be felt, despite procedures written into operating manuals, and despite the fact that disciplinary action is taken against operators who act improperly. The pressure is apparent; its source remains unexplained.

* Another kind of breakdown in the human processes was Hydro's failure to demonstrate a comprehensive follow-up to significant events at Bruce. Hydro could demonstrate that each event is documented and reported in a very timely way, but could not, at that time or later in the inquiry, demonstrate that the follow-up is adequate and comprehensive. The organization appears to break down between the plant and head office and between Design and Operations. The Committee found, as one specific, that a significant event report in 1970 pointed to problems in emergency cooling at NPD. The early insight was not accepted and later studies --in 1976 -- showed that it had been correct.

At the beginning of this set of hearings, Dr. Porter advised the Committee of his concern that the human factors were the weak link in Hydro's nuclear operation. As the hearing progressed, the Committee became increasingly concerned about weaknesses in the human back-up to the engineering, construction and equipment that made up a CANDU reactor. As the hearing was drawing to a close, the Hydro Chairman, appearing before the Committee, conceded that "empire building" was, very likely, a problem in the organization. Mr. Taves, a recent shift operator at the Bruce "A" Generating Station confirmed that the plant operators are unable to communicate their ideas and concerns to the rest of the organization. Drs. Senders and Foley, human factors engineers from the University of Toronto, along with one of their former students, and, for a short time, a Hydro employee, Mr. Kaponeridis, also gave evidence of shortcomings in Hydro's handling of the human dimension.

The substantiation of concerns that the Committee was gathering in questioning Hydro witnesses, gives the Committee additional confidence in concluding that Hydro must rethink the way it handles the human resources involved in nuclear operations and must substantially improve its follow-up of significant events. In its interim report, the Committee made specific recommendations to effect these conclusions. As this Final Report was being prepared, Hydro reported to the Committee through Committee staff, on the actions it had taken to implement these recommendations. A comprehensive new system for reporting significant events has been tested and recently implemented. An important feature of that system is the collection of information on the direct effect of 'human factors' during an incident. A computer backed system for classifying and analyzing incidents is being developed to improve follow-up and ensure that lessons are learned. Hydro is also trying to learn how to improve the effectiveness of the human resources in its nuclear facilities. The heavy water plants have been singled out for various pilot programs accompanied by in-depth attitude surveys and recording of overall plant performance.

The Committee commends Hydro for these initiatives and repeats the recommendations from its Interim Report to emphasize their importance and the need for ensuring that the work is carried to a satisfactory conclusion.

> RECOMMENDATION VII HYDRO SHOULD UNDERTAKE A COMPREHENSIVE REVIEW OF PROCESSES FOR DEALING WITH HUMAN RESOURCES TO IMPROVE THE ORGANIZATIONAL CLIMATE AND THE FUNCTIONING OF THOSE PARTS OF THE ORGANIZATION THAT DEAL WITH THE SPECIAL PROBLEMS OF NUCLEAR POWER.

> RECOMMENDATION VIII HYDRO SHOULD TIGHTEN ITS SYSTEM FOR MANAGING THE FOLLOW-UP TO SIGNIFICANT EVENTS IN ORDER TO ENSURE THAT APPROPRIATE REMEDIAL ACTION RESULTS, THAT EVENTS ARE CLASSIFIED BY TYPE AND/OR COMPONENT AND THAT EVENTS ARE CROSS-REFERENCED TO OTHER PLANTS IN A MANNER WHICH CAN BE TRACED THROUGH THE REPORTING SYSTEM.

SPECIAL REFERENCE TO NPD REACTOR

Although the NPD Reactor at Rolphton is, at 22 megawatts, the smallest of Hydro's operating reactors, it received more attention than any other reactor. In fact, the Committee was specially directed to study and report back to the Legislature on the continuing operation of the station.

Several factors accounted for this special attention. First, a group of citizens living in Renfrew County expressed their concerns about the station to the Committee. Second, the station is the oldest in the system and there were special concerns that it may not be as safe as the newer ones. Finally, over the course of the hearings the station was plagued by a number of operating problems that kept attention focussed on it.

To help fulfill its special obligation, the Committee travelled to the plant for a tour of the facility and an open meeting in the nearby community of Deep River. At several points in the hearing, the Committee heard the detailed concerns of the Renfrew County Citizens for Nuclear Responsibility (RCCNR) and the responses of Ontario Hydro, AECL (the owner of the plant) and the AECB. The Committee acknowledges the extensive background work that went into the submissions of the RCCNR. Their participation was extemely important to the Committee process. They helped the Committee gain valuable insights into the recent history of the station and into the regulatory process as it has applied to the NPD reactor. Finally, the Committee received from AECL copies of the correspondence between Ontario Hydro, AECL and the AECB that related to emergency core cooling. That correspondence formed the basis for a final set of hearings on NPD in February of this year.

The NPD Reactor was originally licenced in 1963. The reactor was the first commercial scale reactor in Canada and was built to demonstrate the feasibility of the CANDU system. On the basis of the early operation of NPD, the 200 megawatt station at Douglas Point and two 540 megawatt units at Pickering were built to launch the Canadian nuclear program.

As the first reactor of its kind, NPD required original regulatory criteria. Licencing criteria for a nuclear reactor include many specifications for certain qualities of materials and equipment and for specified levels of control and instrumentation. An important class of criteria are those that relate directly to the public safety risk raised by the operation of the reactor. In the case of NPD, the public risk criteria were set to show that the risk from a nuclear reactor are less than from a coal-fired reactor. The specific risk level was that the chance of one individual dying as the direct result of the operation of the reactor should not exceed 10^{-2} (one death per 100 years of station operation). Many of the criteria have been changed for subsequent reactors that are much larger, more complex and operate with fuel that is far more powerful. Equipment specifications have been changed. New engineering codes have developed for assessing material quality. The overall risk concept (10^{-2}) has been changed to single and dual failure criteria. The single and dual failure approach is used on all the reactors built after Douglas Point. It establishes limits to the amount of radioactivity that can be released in any single failure accident for which the AECB requires analysis (such as the worst possible failure of the normal cooling system but proper action from the safety systems) or in any dual failure accident for which analysis is required (such as the worst possible failure of the normal cooling system coupled with an inoperative safety system).

When various postulated accidents were analyzed at NPD prior to 1963, the best analytical techniques showed that the public was protected from significant radiation danger by the integrity of the Zircaloy fuel bundle. The fuel bundles would not fail, and therefore significant quantities of radiation could not be released. By 1976 new analytical techniques had been developed which showed that fuel bundles could fail in CANDU reactors under certain conditions. The new analyses were relayed to the AECB and each station was required to show how the new information should affect its continued operation. AECL replied for NPD by showing that the plant, if allowed to operate without any changes, would continue to meet its original public risk licencing criteria, even though there could be fuel sheath failures under certain accident conditions and even though, under those conditions, the plant could not meet either the single or dual failure criteria applied to most of the newer reactors. The AECL also showed, however, that certain modifications could reduce the probability and level of emissions in potential accident situations. Single and dual failure criteria could be met.

All equipment and procedures necessary to activate the proposed modifications are now in place. Most have been accepted by the AECB and are implemented. Among the most important were those that enable the calandria spray system to continue in operation following a loss of coolant accident (LOCA). This modification was in place and accepted in 1977 and brought the plant within the dual failure limit. All of the additional modifications designed to bring the regular emergency cooling system back to its original effectiveness have not been accepted by the AECB. For one of the two modifications not yet accepted, boiler crash cooldown, extensive and time-consuming stress analysis has been requested. That modification must be approved and implemented before the station will meet the single failure criteria. In fact, recent analysis has shown that the impact of the other modifications caused the single failure criteria to be exceeded by a factor of two - considerably more than had been originally estimated.

In its Interim Report, the Committee was critical of the AECB for allowing the plant to operate while the modifications to bring the releases in a dual failure within limits were installed. The Committee believes that the plant can be allowed to operate while modifications that will bring it within the single failure limit are being analyzed.* Several factors influenced this very critical decision. First, the plant is, and has always, operated within its original licencing criteria. Although these criteria are not as stringent as the single and dual failure limits applied to later reactors, the Committee considers them adequate for a reactor of the size and location of NPD. Second, NPD operates with fuel that is not as powerful as the fuel used in other reactors. The importance of the low fuel rating is that there are no significant quantities of gaseous fission products that would release from the fuel immediately if the fuel bundles were to fail. When the performance of the Douglas Point reactor's emergency cooling system was shown to be not as good as had been presumed in its original Safety Report, the AECB reduced the reactor's power to that of NPD. The third factor considered by the Committee is that failure to meet the single failure results in a lower release of radioactivity than the inability to meet the dual failure criteria. The release for the worst single failure accident is 150 curies; for the dual failure accident, it was 6,800 curies.

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*See dissent of Members Foulds, Gigantes and Mackenzie

There is, however, another concern about NPD. The Committee found that the documentation concerning NPD is far from adequate. The key safety document, originally called the Final Hazards Report, is no longer accurate but has not been replaced. Various analyses and descriptions of proposed modifications are now just appended without being cross referenced to the safety report or to each other. Incompleteness of safety analysis was revealed when it was recently learned that an earlier modification had inadvertently increased pressure in the containment system so that it would leak radioactive tritium to the control room and atmosphere during certain accident situations. There have been many advances in the art of analyzing the capability of materials and components in nuclear power plants since NPD was designed some 20 years ago. The latest analytical techniques should be applied to NPD to see if there are any other problems that might appear.

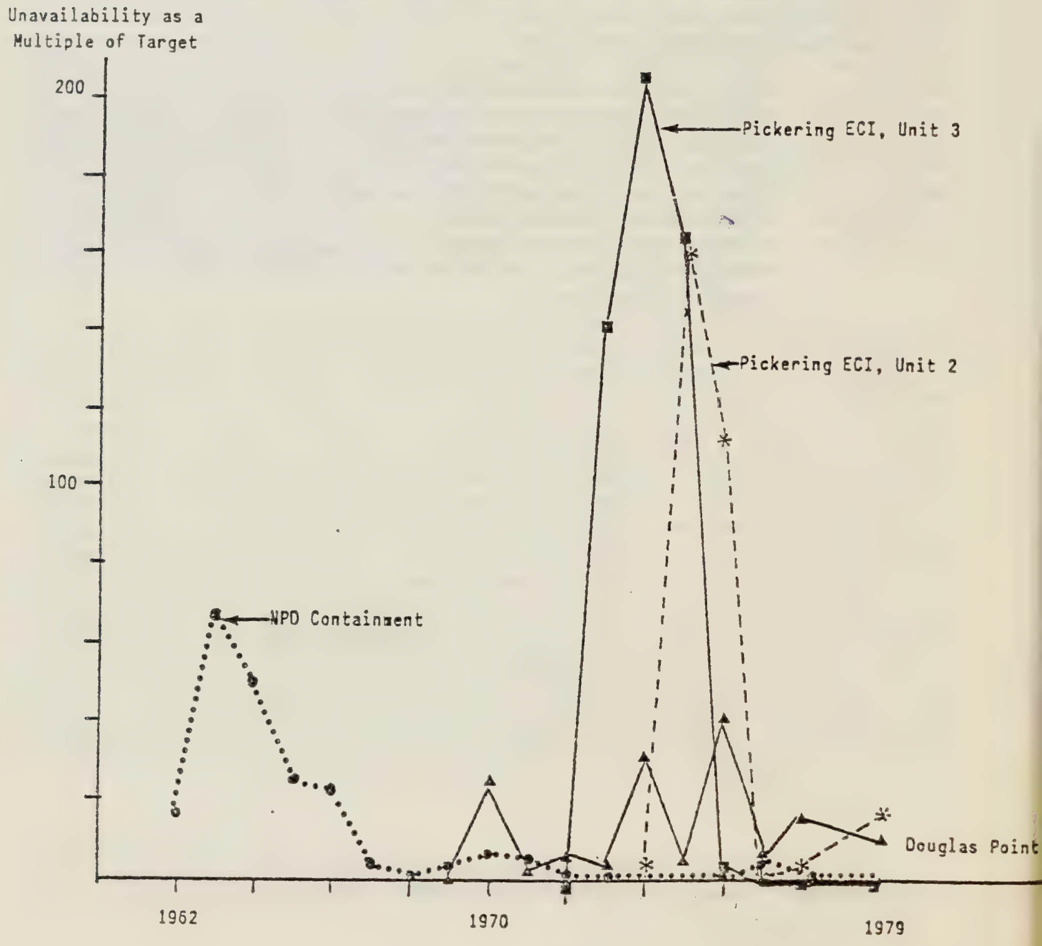
NPD requires a major engineering review. Completion and full documentation of the review would place the AECB and the public in a much better position to judge the acceptability of the reactor. Such a judgement will become increasingly important as the reactor continues to age.

The Committee recommends that:

> RECOMMENDATION IX ONTARIO HYDRO SHOULD ENSURE THAT A COMPLETE ENGINEERING REVIEW OF THE NPD STATION IN ITS MODIFIED STATE IS UNDERTAKEN AS A BASIS FOR A NEW FINAL HAZARDS REPORT THAT REFLECTS BOTH THE PLANT MODIFICATIONS AND THE MOST CURRENT RESEARCH INFORMATION. AFTER AECB REVIEW AND APPROVAL THE REPORT SHOULD BE PRINTED WITHIN TWELVE MONTHS AS A NEW SAFETY REPORT AVAILABLE FOR PUBLIC SCRUTINY.

EXHIBIT

UNAVAILABILITY OF SELECTED SAFETY SYSTEMS AT THREE STATIONS



CHAPTER 3

THE REGULATION OF NUCLEAR POWER SAFETY

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The safety of the nuclear power industry has been regulated in Canada by the Atomic Energy Control Board (AECB) since 1946. At that time, the Atomic Energy Control Act set up the Board and gave it exclusive authority to regulate, license and monitor the health, safety and security of all works that involve atomic energy. This gives the AECB effective control over the full nuclear cycle -- mining, milling, fuel fabrication, reactor operation, waste management -- as well as the use of radioactive materials in other products, such as smoke detectors or medical equipment.

The AECB in 1979-80 had a staff of 178 plus 7 temporary staff members and a budget of $7 million per year. In contrast, the Nuclear Regulatory Commission (NRC) in the U.S.A. had 2,700 employees, 600 consultants and a budget of $330 million in the same year. Canada has 12 operating reactors; the U.S.A. has 75 to 80. The AECB operates by granting licenses and giving permission at important stages. In sequence the important milestones are:

- site approval
- construction licence
- permission to load fuel
- permission to go critical
- graded set of permissions to increase power
- full operating licence
- operating licence renewal

At each stage the Board requires the pre-filing of appropriate documentation which is analyzed and verified by the Board staff. Often extensive dialogue ensues between the AECB staff and the licensee before the licence is issued or permission granted.

In the course of coming to its own conclusions on the acceptability of Ontario's reactors, the Committee became thoroughly familiar with the Canadian nuclear regulatory process. The Committee found that while there are several good features in the regulatory process as it exists, the public has not always been protected by the process as effectively as it could be. Changes of a substantial nature are required. The balance of this chapter will deal with each of these points in turn.

GOOD FEATURES WORTH STRENGTHENING

The regulatory approach has evolved considerably over the 33 years the AECB has been in operation and, perhaps most critically, over the approximately 20 years that it has been regulating commercial sized reactors. Several features of the process are very good. In some cases they need strengthening, but in concept they are worth retaining.

Onus on the Owner/Operator

In the U.S., the NRC has developed a specific set of technical design criteria that each reactor must meet in order to be licensed. In Canada, the AECB has defined a set of general output standards for reliability of systems and permissible radiation emissions under normal or accident conditions. The owner/operator of the plant is responsible for design, engineering, construction and operating procedures to ensure that the plant meets the standards. (In Ontario, Ontario Hydro operates all the nuclear generating stations but AECL owns the nuclear portions of the NPD station at Rolphton and the Douglas Point station.) The AECB checks the analysis and documentation, and monitors plant operations through resident inspectors.

The Committee is satisfied that the Canadian approach is sound and appropriate. The Canadian approach encourages the owner/operator to develop a capability for safety research and analysis. Specifically, Ontario Hydro has groups concerned solely with nuclear safety within its Design and Development Division and its Nuclear Generation Division. AECL has a separate Safety Engineering Group within its Engineering Company. These groups are involved in all aspects of the design, participate in all design reviews, audit the quality of operation of safety-related systems, and are available for follow-up of significant events as they occur. This built-in responsibility for safety is the best assurance that safety decisions are appropriately integrated with operating practices and procedures. And, by making the owner/operator initially responsible for safety, there is always the possibility that better safety systems are designed and implemented than the regulator would have required or even considered possible.

Basic Standards Are Sound

The basic safety standards have evolved over the past twenty years from the licensing of NPD to the current approach to Darlington. There is, in the minds of the Committee, considerable unproductive and unsatisfying vagueness about the detailed definition and application of the standards. However, the basic approach has, in each case, been quite straightforward.

- The NPD reactor was licensed on the basis that it must be safer than an equivalent coal-fired facility. Specifically, probable releases from possible accidents must be shown to fall within limits that would result in no more than one fatality every 100 years from the operation of the plant.

- The Douglas Point reactor was licensed on the basis that the most exposed member of the public would not have more than one chance in a million per year of being killed by the operation of the station.

- The Pickering, Bruce and Darlington plants are licensed to meet reference dose limits and reliability standards calibrated to ensure that the risk to the public is acceptable in relation to the risks from other industries.

Although the reference dose limits are expressed in fairly technical terms, they can be expressed in three plain statements.

1. A single failure accident should be a very infrequent event (say once every three years) and its consequences should fall within the 500 millirem to the most exposed individual "safe limit" set for releases during normal operation.

2. A dual failure accident should be expected to occur very rarely (no more than about once in every 3,000 reactor years) and its consequences should be well below radiation levels that are certain to cause an immediate fatality.

3. A triple failure, or catastrophic accident should be expected to be a highly improbable event.

It is important to note that while these three statements seem to define the basic Canadian standards, they are not expressed in these terms anywhere in any of the material provided the Committee by Hydro, AECL or the AECB. In fact, Hydro witnesses stated their conviction that the only standards applicable are the first two. On the other hand, we found that a good deal of the debate between Hydro and the AECB centred on AECB requirements that Hydro believes are aimed at meeting the third. One problem of failing to recognize the third basic principle is that the industry has never fully analyzed the consequences of the more improbable accidents. As well, there are instances where the AECB has granted an exemption to a particular standard. At the Bruce "A" reactor, the dual failure release limit is not met for an accident that includes the worst possible loss of coolant and each of two particular failures of the containment system. The exemption is granted because it is presumed that the two failures are highly improbable.

Despite the soundness of the basic regulatory approach, there are difficulties in applying them, as indicated by the exemptions and the lack of clear articulation. The AECB set up a group called the Inter-Organizational Working Group (IOWG) made up of representatives of the industry and the regulator and chaired by Dr. Paskievici of the University of Montreal. This group was given the responsibility of reviewing and updating the general principles as a first step in the current work of the AECB to develop a more comprehensive set of regulatory guidelines.

The approach recommended by the IOWG is conceptually more consistent than the current approach and does toughen up some of the release limit standards. Release limits are set by the probability of occurrence rather than single and dual failure, recognizing that some accidents are more likely to occur than others, and they are set for some of the more improbable accidents including some that may fall into our category 3 above. Release limits for normal operation and for some of the accidents that correspond to the reference single and dual failure accidents are lowered. Each of these features contributes to the attractiveness of the IOWG approach.

The IOWG approach does, however, have certain drawbacks that are, in the minds of the Committee, sufficient to cause it to be rejected in favour of strengthening the current system. One drawback of the IOWG proposal is that, as it was written, it appears to offer the theoretical loophole of allowing accident

sequences to be subdivided into small discrete elements that are each highly improbable, thereby increasing the allowed release limits. This is a specific aspect of the general concern of the Committee that probabilities should be used only as a guide and not as the exclusive licensing tool. Second, the IOWG approach has the drawback of taking the regulation of nuclear safety even further away from the understanding of even the most well informed layman, by stating the criteria in a way that can only be understood in very technical terms. As well, by allowing designers to work through 'fault trees' in assessing probabilities, credit can be taken for the operation of process systems that in current accident analysis are assumed to be completely inoperative. Finally, the Committee noted the personal view of the President of the AECB that at least two of the IOWG recommendations can be interpreted as a loosening of current standards. The Committee believes, on the basis of its knowledge of nuclear safety, that it is entirely inappropriate to loosen any nuclear safety standard.

The Committee believes then that the AECB should continue with its current basic approach to standard-setting. But the approach must be strengthened. One concern is that there has been no study of the likelihood and possible consequences of the highly improbable worst set of accidents possible in a CANDU reactor. The AECB has contracted with Dr. Rogers of Carleton University to study what can happen in a physical sense if a core melt does occur when, one after another, each of the reactor's cooling systems or heat sinks is lost. His study will take information available around the world and apply it to the CANDU reactor. The Committee supports this initiative. Until this study was commissioned, the AECB has stood with AECL and Ontario Hydro in their conviction that a much more detailed study is unnecessary. Their argument is that the probability of catastrophic accidents is very low and resources are better devoted to ensuring that accidents do not happen. The AECB joins the industry in arguing that no study can be definitive. Studies of potential catastrophies, it is argued, will always be subject to intense academic criticism that will confuse the public and make it unnecessarily skeptical of nuclear power. They cite the $5 million study completed in the U.S.A. under the chairmanship of Dr. Rasmussen of the Massachusetts Institute of Technology that was soundly criticized as soon as it was published, even though the credentials of Dr. Rasmussen and many of his colleagues are impeccable. The basis of the technical criticism is that confidence in predicting events that cannot be demonstrated in relevant experience is not very high. There will always be unanticipated human actions or missed cross-links that render the prediction invalid - either significantly too high or significantly too low.

In the end the study can only show what is already known: a catastrophic accident is possible but unlikely. The Royal Commission on Electric Power Planning supported the industry on this issue. In fact, this was the only Committee conclusion with which the Royal Commission failed to agree.

The Committee believes, however, that the industry and the Commission are underestimating the public's need to know the risk it is accepting in allowing nuclear power plants to operate in Ontario. As well, the Committee is aware that the Rasmussen study is acknowledged to have been extremely valuable in developing the capability to analyze nuclear accidents, in identifying potential accident sequences, and in alerting public authorities to the nature of the required civil response to a catastrophic nuclear accident. It should not be necessary for a Canadian study to duplicate each and every aspect of the massive Rasmussen project: some things can be learned from that experience and the extensive debate

that followed publication of the report and summary. A study for a CANDU reactor would cover the likelihood of a range of the accidents through fault tree analyses that incorporate the effect of human actions and the consequences identified by Dr. Rogers. The slowdown in new reactor orders should have made a good number of design analysts available to complete the work. With guidance and direction from outside the industry, the study could draw on all recognized experts. The several million dollar cost of the study may appear high, but it is insignificant in comparison to the billions of dollars spent in the construction of each Ontario Hydro station.

A special concern of the Committee is that this type of study should be the responsibility of the AECB and through it, the Federal Government. However, the study itself is of major concern to the people of Ontario. The Government of Canada should be given an opportunity to accept its responsibility. If it does not act, the Province must be prepared to do so.

> RECOMMENDATION X THE AECB SHOULD COMMISSION A STUDY TO ANALYZE THE LIKELIHOOD AND CONSEQUENCES OF A CATASTROPHIC ACCIDENT IN A CANDU REACTOR. THE STUDY SHOULD BE DIRECTED BY RECOGNIZED EXPERTS OUTSIDE THE AECB, AECL AND ONTARIO HYDRO. IT SHOULD BE FUNDED BY A SPECIAL GRANT FROM THE FEDERAL GOVERNMENT. IF THIS STUDY IS NOT COMMISSIONED BY JULY 31, 1980, THE PROVINCE OF ONTARIO SHOULD ENSURE THAT IT IS UNDERTAKEN.*

In general, the Committee believes that the Board should continue with its current approach to standard-setting: aiming at outcomes and reliability levels rather than specific equipment specifications and building on the simple, understandable, three-step approach.

> RECOMMENDATION XI THE AECB SHOULD MAKE SIGNIFICANTLY MORE SPECIFIC ITS OWN CURRENT CRITERIA FOR BOTH SINGLE AND DUAL FAILURE ACCIDENTS AS WELL AS FOR MINIMIZING THE PROBABILITY OF A CATASTROPHIC ACCIDENT, INCORPORATING WHERE APPROPRIATE, THE TIGHTENING IMPLICIT IN THE REPORT OF THE INTER-ORGANIZATIONAL WORKING GROUP (IOWG).

Staff are Competent and Independent

In requesting and receiving from Ontario Hydro, letters and internal memorandums between the corporation and the AECB, the Committee gave itself and the public a unique insight into the complex, formerly secret, often confusing process for regulating the safety of nuclear reactors in Ontario. The Committee found that lengthy discussions and arguments go on between regulator and licensee on many, many aspects of the licence. Many of the conclusions drawn by the Committee on the strengths and weaknesses of the regulatory process came from its examination of that correspondence. Much of the Committee's confidence that the reactors operating in Ontario are 'acceptably safe' came from observing the depth of analysis and questioning that goes into the design of an operating reactor.

*See dissent of Members Ashe, Belanger, Hennessy, Leluk and Williams

One specific concern the Committee examined in some detail relates to the boilers in the Bruce A Generating Station. In any generating station producing electricity from thermal power (heat) the boiler is the critical component that turns the heat from the thermal source into steam that turns the turbines of the electricity generators. In a CANDU station the heavy water coolant, heated in passing through the calandria, flows through thousands of small tubes inside the huge steel boilers. The boilers and their adjoining steam drums are normally filled with ordinary or light water that boils into steam in the top half of the steam drum. Steam in the top of the steam drum is piped to the turbines, condensed and cooled, and returned as water to the boilers to be converted into steam again.

The boilers at Bruce A are a unique design that has caused some problems. In addition, Hydro made a critical decision to put a good portion of the boilers outside containment as part of a general design philosophy at Bruce of putting as much equipment as possible outside containment. The objective of this philosophy is to reduce the exposure of plant personnel to radioactive tritium while carrying out maintenance and upkeep duties during normal reactor operation. In Pickering the boilers are entirely within containment and were designed to a Class III engineering standard. The location of the Bruce boilers in the containment wall made them, in the opinion of the AECB, a part of the containment boundary. In 1971, the AECB imposed a requirement for a more stringent, Class I engineering standard for the Bruce boiler shells. Hydro contacted its supplier, Babcock & Wilcox, and amended the contract to provide for the necessary upgrading. This included a higher level of inspection of the material and fabrication, more in-service inspection and more detailed stress analysis. The stress analysis had to show how the boiler shell would accommodate the worst forces that could be imparted by the piping during any operation.

Babcock & Wilcox performed the upgrading tasks required of them and their work was reviewed and approved by the AECB. During the plant's commissioning and before there was any power coming from its reactors, it was discovered that the unique boiler design was creating unusual stresses at the intersection of the boiler and the steam drum. Since the fall of 1975 when this phenomena was discovered, the boilers have been subject to unceasing scrutiny and analysis. From the Committee's point of view, several aspects of the long history of the Bruce A boilers were important in demonstrating that the Canadian regulatory process is working to ensure that high standards of safety are maintained in Canadian reactors. Despite the limited numbers of staff, the AECB was able to:

- identify the critical design change that required the Bruce boilers to be of a higher standard than Pickering boilers

- follow the details of the commissioning tests to pinpoint critical operating factors not considered in the original stress analysis.

- recognize the need for greater expertise and get it by contracting out the stress analysis review and then adding staff expertise.

And, the Committee was able to see that Ontario Hydro has operated the station very cautiously while the problems continue to be analyzed. For example, in 1976 the analysis showed that the cool-down rate should be limited to 2°F per

minute from the specification value of $5^{o}F$ per minute. Hydro proposed and AECB accepted an operating limit of $1^{o}F$ per minute. Questions about the boilers continue today and problems have continued to appear. The boilers are being operated within restrictive limits to reduce the possibility of inadvertent excursions beyond allowable stress limits. Innovative strain gauges are being installed to provide data for further analysis. It could be well into 1981 before a 'definitive' analysis will lead toward some final resolution of the problem. So long as the vigilance of the AECB continues, and that vigilance is backed by an open information policy to ensure that the final decision is publicly justifiable, the Committee is satisfied that the problem can be left to Ontario Hydro and the Control Board.

One of the great strengths of the Canadian system is, it seems, the individuals involved in it. The Bruce correspondence show that the AECB staff is competent and independent. They ask many, many questions on the documents submitted. They ask for a great deal of information. The staff seem totally unconcerned by Hydro's complaints that too many questions are being asked and that the process costs too much money. At this time, with three stations incorporating 12 reactors at various stages of construction, the Federal Government should not be looking to the AECB staff as a source of quick 'cutback' economies.

> RECOMMENDATION XII THE GOVERNMENT OF ONTARIO SHOULD PUBLICLY URGE THE FEDERAL GOVERNMENT TO ENSURE THAT THE AECB IS ADEQUATELY FUNDED, PARTICULARLY IN LIGHT OF THE SIGNIFICANCE OF ITS CURRENT AND ONGOING WORK AND THE PUBLIC TRUST IT MUST FULFILL.

REGULATORY PROCESS OCCASIONALLY FAILS

Although the Canadian regulatory system has its strengths, as outlined in the preceding sections, it also has some significant weaknesses. In the next section, the report will set out the areas of weaknesses and recommend specific corrective actions. In this section we will set out two instances the Committee discovered where the regulatory process did not do what the Committee believes the public would have expected it to do.

Bruce "A" Shutdown Systems

The Bruce "A" Station was designed and is operating with two independent, fast shutdown systems. The first involves shutdown rods dropping into the calandria to absorb the excess neutrons that cause continuous "fissioning". The second is the injection of a chemical 'poison' into the moderator to accomplish the same function. At Pickering the shutdown system is insertion of the rods and dumping the moderator.

The correspondence indicates that there was continuing confusion whether the second fast shutdown at Bruce was an AECB requirement, or an added feature put forward by Ontario Hydro. One result of the confusion is that the second shutdown system designed and installed by Hydro at the Bruce "A" plant is not able

to react as quickly to certain kinds of accident possibilities as the first. The AECB believe both should have the same characteristics but have now conceded that it could be counter productive to 'backfit' a new design that would offer the same capabilities for both systems. The Committee believes that the public does not expect that a critical safety system would be given 'de facto' approval while not meeting the requirements of the AECB merely because of loose communications.

Early Licensing of Bruce "A"

The Bruce correspondence indicates that the licensing process at that station was extremely difficult. The AECB seemed to ask more questions and require more analysis on Bruce than had been the case with Pickering. Documentation fell behind. Construction was nearly completed and the reactor was ready to operate but the AECB staff did not yet have documents that they had expected to receive one year before the Board issues an operating licence. The example cited earlier of the analysis and checking required on the boiler shells indicates the reason the documentation is required for such a long time. The Chairman of Ontario Hydro visited the President of the AECB in Ottawa to impress upon the Board the economic significance of avoiding delay in starting- up the reactor. The President of the AECB expressed in a letter to the Chairman of Ontario Hydro his concern that the regulatory process was coming under increasing public scrutiny, requiring extra vigilance from the AECB. However, the AECB relented and issued a licence to operate at 63% of full power. Ontario Hydro, in turn, gave a corporate commitment to complete certain documentations in six months. The reactor began to operate at the reduced power level. The documentation was not ready in six months. When finally complete, the documentation showed that for some dual failure accidents with significantly impaired containment, the criteria are not met at power levels over 63%. A licence to operate at 88% of full power was issued while the AECB pressed Hydro to design and implement an emergency coolant injection system that will keep dual failure releases within limits. Hydro does not accept the fact that they have been granted an exception. Hydro and the AECB continue to disagree whether the critical accidents are credible enough to be required for the dual failure release limits. The Committee is confident that the public has the right to expect that the process of licensing the largest nuclear complex in the world would be carried out with far more precision and adherence to the regulatory requirements that has been the case.

MORE CHANGES NEEDED

The Committee is aware that the responsibility for regulation of nuclear safety is a federal rather than a provincial responsibility. Therefore, any change recommended by this Committee can be construed as being outside its jurisdiction. However, the Committee has devoted a good deal of time to studying the current regulatory process and is convinced that the process must change if the public is to have confidence in the system, and consequently, in the acceptability of nuclear power. Two areas require change. First, the Board must make its judgements clearly and ensure they are enforced. In addition to improving public confidence, this will also have the beneficial effect of improving the interaction between the Board and the regulated nuclear operator. Second, the composition and apparent functioning of the Board itself must change to improve public confidence in the safety of nuclear reactors.

Reducing Vagueness
and Uncertainty

The Bruce correspondence revealed that there was considerable uncertainty between Hydro and the AECB on exactly what was required in the licensing process. In many of the appearances of Hydro and the AECB, the Committee was able to confirm that the differences in opinion still exist. In fact, in the very last appearances of Hydro and AECB witnesses, it became apparent that a critical question still unresolved is whether the failure of Bruce "A" to meet the dual failure criteria for certain postulated accidents is an exception for that plant or not really a requirement.

Uncertainties that continue today include the:

Timetable

The AECB has said that documents in support of an operating licence must be available one year before the licence is issued. The last plant was licensed before the documents were finished. It is unclear whether the one year rule still applies. In other instances the Board has requested certain action. The requests lead to long arguments and the transfer of great volumes of paper. It is unclear whether there are any end points to debate over Board requirements.

Criteria & Standards

Many uncertainties in the definition and application of criteria and the standards that do exist, continue to confuse. The Canadian approach is to focus its regulation on outputs --reliability and expected performance of systems -- rather than inputs -- the technical specifications necessary to achieve these outputs. This focus should continue. But a great deal of uncertainty remains about what the output targets are and how they are proved. Arguments continue over which accidents must be analyzed. There were contradictory statements from AECB staff over the reliability target for process systems. There are continuing debates over the definition of availability. It is disconcerting for laymen to observe so much confusion in the regulatory process. The confusion is clearly frustrating to the participants as well.

Ongoing Enforcement

The AECB posts resident inspectors at each station except NPD. And, it requires regular reports from the operator on the performance of the various safety systems as evidenced by their use and testing. Over the years the reporting of availability information has changed almost continuously as Hydro and the Board have sought a definition of 'unavailability' that is both simple and yet able to cope with the complexity of nuclear technology. The current system is still not satisfactory. It shows unavailability levels for certain systems that fail to meet targets. But Hydro responds that the information is not meaningful because unavailability does not mean inoperability in an emergency. The implications of failure to meet targets remain unclear.

Powers of Board & Staff

The correspondence revealed to the Committee considerable uncertainty over the powers of the Board and of its staff. It is clear that the Board itself has the ultimate power to grant or withhold a licence. It is also clear that Ontario Hydro has no question about that authority. However, below that ultimate power lies a great sea of uncertainty about what the Board can request of a licensee, when that request becomes an order, whether the request or order can be made by a staff member, and, given this uncertainty, under what circumstances Hydro staff can refuse to comply with a request from AECB staff. This uncertainty gives rise to long arguments between Hydro and AECB staffs. The arguments may not in themselves be improper, but they do lead to concern that delay can become a tactic for failing to act.

This confusion and uncertainty must be overcome. The system as it operates today depends too much on the strength of individuals.

RECOMMENDATION XIII THE AECB SHOULD SET OUT A SPECIFIC TIMETABLE FOR THE RECEIPT AND APPROVAL OF DOCUMENTS AT EACH STEP IN THE LICENSING PROCESS.

RECOMMENDATION XIV THE AECB SHOULD DEFINE AS CLEARLY AS POSSIBLE THE KEY PHRASES, SUCH AS "REQUEST" OR "ORDER" THAT FORM PART OF THE ON-GOING COMMUNICATION WITH THE LICENSEE AND SHOULD TELL THE LICENSEE EXACTLY WHAT AUTHORITIES HAVE BEEN GRANTED TO STAFF MEMBERS.

RECOMMENDATION XV THE AECB SHOULD, AS A MATTER OF ROUTINE, BRING DEBATES WITH A LICENSEE TO A FIRM CONCLUSION BY INDICATING, AT THE APPROPRIATE TIME, THE BOARD'S DECISION AND THE REASONS THEREFORE. WHERE THE BOARD IS NOT YET IN A POSITION TO MAKE A DECISION IT SHOULD PLACE AN APPROPRIATE TIME CONSTRAINT ON THE DURATION OF UNRESOLVED DISAGREEMENTS RELATING TO VITAL SAFETY MATTERS.

RECOMMENDATION XVI THE BOARD SHOULD SET OUT THE FUNDAMENTAL REQUIREMENTS FOR THE CRITICAL SYSTEMS IN A NUCLEAR PLANT — PROCESS SYSTEMS, EMERGENCY COOLING SYSTEMS AND CONTAINMENT SYSTEMS — AND THE WAYS IN WHICH ACCIDENT ANALYSIS MUST BE DONE TO SATISFY THE REQUIREMENTS.

RECOMMENDATION XVII THE BOARD SHOULD SPECIFY THE ROUTINE REQUIREMENTS OF ITS OWN ON-SITE INSPECTORS, DEVELOP APPROPRIATE DAY-TO-DAY OPERATIONAL AUDITING ROUTINES AND BEGIN A REGULAR SYSTEM OF INSPECTION REPORTS.

Change Board
Composition & Functioning

The Atomic Energy Control Board itself, as opposed to its staff and the processes that surround it, is, in the end, the critical element in public confidence in the adequacy of safety regulation of nuclear plants. Even though the Committee itself has been able to conclude that, at this time, and based on the information it has examined, Ontario's nuclear plants can be considered safe enough for continued operation, it recognizes that the ongoing confidence of the public rests with the Board. In the view of the Committee, the Board must recognize that this is one of its most important functions. The Board must not only satisfy itself that nuclear operations are safe enough, it must, through its composition and functioning satisfy the public. The existence of this Committee is proof that the Board has not satisfied the public.

There are five aspects of the Board's current operation that do not lend themselves to improved public confidence.

1. Board membership is from the technical community including the National Research Council, the university community and the medical profession. If one of the key jobs of the Board is to balance technical considerations with public needs, this technical membership should be supplemented by members drawn from the general public.

2. Board role as evidenced by the Bruce correspondence is very limited. The Board meets infrequently and there was no evidence that the Board itself pushes the staff to take a tougher stand or to try to further tighten a particular approach.

3. Board secrecy about its proceedings and decision making makes the public almost completely unaware that the Board is performing any function at all. Without public awareness, there can be no public confidence.

4. Board powers appear to limit the Board to issuing or withdrawing a license, allowing full or reduced power operation. There is some concern that this is such an extreme action that the Board may sometimes be reluctant to take it.

5. Board staffing relies too heavily on in-house expertise, reducing the breadth of the technical community informed about nuclear power and raising the critic's concern that the Board is receiving opinions from too narrow and too limited a group.

The Committee is aware that the Board is operating under some constraints because new legislation that would have moved the Board into a more desirable open direction did not get passed before the last Federal election. The Board may be required to work for several more years under the current legislation. The Committee urges the Board to take all the steps it can to increase public awareness and public confidence in its proceedings by holding public hearings and, by making its decisions, and reasons for decision, public. The Committee notes that as this report was being prepared the AECB did develop a new public

information policy that will significantly increase public access to and awareness of Board decisions. If fully implemented it will also ensure public access to information about each plant. The Committee endorses this new direction and further supports it by recommending that:

RECOMMENDATION XVIII THE AECB SHOULD STRIVE TO ADOPT THE MOST OPEN AND PUBLIC POSITION POSSIBLE BY BROADLY INTERPRETING ITS CURRENT LEGISLATION.

RECOMMENDATION XIX THE AECB SHOULD BROADEN ITS MEMBERSHIP TO INCLUDE REPRESENTATION FROM THE GENERAL PUBLIC AS WELL AS THE INFORMED TECHNICAL COMMUNITY.

RECOMMENDATION XX THE AECB SHOULD SEEK AN INCREASE IN ITS FUNDING TO ENABLE IT TO INCREASE ITS CONTRACTING FOR INDEPENDENT OUTSIDE RESEARCH INTO MATTERS OF NUCLEAR SAFETY.

RECOMMENDATION XXI THE AECB SHOULD REPORT TO THE HOUSE OF COMMONS THROUGH A MINISTER OTHER THAN THE MINISTER RESPONSIBLE FOR AECL.

RECOMMENDATION XXII THE AECB SHOULD MAKE ITS PROCEEDINGS OF DECISION MORE WIDELY KNOWN. ITS MEETINGS SHOULD BE OPEN TO THE PUBLIC UNLESS THERE IS A REASON FOR KEEPING ONE CLOSED.

RECOMMENDATION XXIII THE AECB SHOULD WORK WITH ITS LICENSEES TO ENSURE THAT DOCUMENTS MADE AVAILABLE TO THE PUBLIC ARE, TO THE GREATEST EXTENT POSSIBLE, ACCURATE, COMPLETE AND COMPREHENSIBLE.

RECOMMENDATION XXIV THE RULES UNDER WHICH THE BOARD OPERATES, INCLUDING SPECIFIC LICENSING CRITERIA, SHOULD BE THE SUBJECT OF PUBLIC HEARINGS WHEN FORMULATED OR CHANGED. THE AECB SHOULD HAVE GENERAL POWERS OF INTERPRETATION AND THE POWER TO GRANT EXEMPTIONS. INTERPRETATIONS AND EXEMPTIONS MUST, HOWEVER, BE PUBLICLY EXPLAINED IN A TIMELY MANNER IN THE BOARD'S REASONS FOR A PARTICULAR DECISION.

DISSENTS

DISSENT OF THE FOLLOWING MEMBERS: JIM FOULDS, EVELYN GIGANTES, BOB MACKENZIE

Following the Three Mile Island accident and the leak of then-secret documents concerning "incidents" at the Bruce nuclear reactors, the Select Committee was forced to acknowledge public concern in Ontario by changing its work agenda and spending several months of hearings in examination of the safety of Ontario's CANDU reactors.

The difficulty of reaching an objective judgement on the "acceptability" of risk associated with Hydro reactors is extreme. The judgement is made in circumstances which mean that a negative judgement would have enormous economic implications for the province. The operation of the Pickering reactors and the Bruce reactors has become an integral part of the electricity supply in Ontario, and it is inconceivable that this dependence could be phased out quickly or without severe financial consequences.

Given this framework of circumstances, it is inevitable that any reasonable person would conclude that the risk associated with the operation of Pickering and Bruce must be accepted. But a judgement of this kind should not be taken as absolute - it is a judgement based on dependence, and a judgement which relates risk to the virtual impossibility of identifying an immediate alternative.

The public of Ontario looks to the Select Committee for a judgement of whether Hydro's reactors are "acceptably safe". If the conclusion of the Committee is conditioned by supply and financial considerations, it is vital that the public be given a clear understanding of the relativity of the Committee conclusion. In spite of the numerous indications of dissatisfaction with safety matters which are outlined in the Committee report, the report in no way addresses the element of relativity which must so strongly condition any current judgement of the "acceptability" which the Committee had to take into account.

This is a serious failing in the Committee report. We find this particularly regrettable in view of the thorough evaluation that the Committee gave to this question and the sincerity with which all members have approached the problem. Nevertheless, the interested reader of the report is not informed that supply and economic considerations have formed the context, the very atmosphere, in which the Committee was forced to evaluate "acceptable safety". In its most extreme form, the logic of the existing evaluation can lead to a judgement which is based on the following circular reasoning: The public asks the Committee to judge if existing reactors are "acceptably safe". The Committee notes that the public has historically accepted the operation of these reactors. Therefore, the public has accepted the safety of the reactors. Therefore, the reactors are acceptably safe.

The examination of the tautology contained in this kind of reasoning points to the necessity of ensuring that the public be given an explicit explanation of the factors which lead the Committee to <u>recommend</u> that the public be willing to accept current risk from the operation of Pickering A and Bruce A. The failure of the report is that the omission of this information suggests that the acceptability of current reactors is an absolute judgement, and that it can therefore be extended to endorsation of constructing more reactors. In fact, the current dependence on Pickering A and Bruce A should not be the grounds for

extending supply and economic dependence on nuclear-generated electricity. Nor should the current dependence on these facilities be confused with the questions of whether the public should accept the additional risk associated with additional reactors. And because the report is limited to examining the question of reactor safety, it does not explore fully the inadvisability of an electrical system as large as Ontario Hydro's becoming only dependent on one source of power for electricity. We hope in the Committee's future work the question of a balanced mix for the system will be fully addressed. But the present report of the Committee at least allows the confusion between dependence and acceptability, if it does not actively promote it.

The failure of the Committee report on this count is most clearly demonstrated by the recommendation that the NPD reactor at Rolphton be permitted to continue in operation. The report outlines a series of major concerns about NPD which were examined by the Committee: The original licence criteria do not meet current licence standards; design inadequacies have been identified and are not yet corrected; equipment failures make operation sporadic (38% capacity in 1979). In addition the Committee learned that what power is produced by NPD is not either a significant source of supply for the grid or an economic source of electricity.

Despite its specific findings about safety concerns associated with NPD, the Committee report states that "the plant should be allowed to operate while modifications that will bring it within the single failure limit are being analyzed." The report cites no reason of supply or economics for this conclusion, but instead gives stress to the fact that the total consequences of an accident at the NPD reactor would be lower than at larger reactors. While this is obviously correct it does not mitigate the relative risk to those smaller number of people who might be exposed to radiation in the event of a serious accident at NPD. Nor does it answer the question of why risk beyond the levels of current criteria should be accepted, especially when the reactor is not one on which Ontario depends for supply or economic reasons.

While the conclusions of the report concerning the NPD reactor are the clearest sign that the majority of the Committee has failed in its attempt to define "acceptable risk", the fact that the report does not recommend the closing of the Douglas Point reactor has to be taken as further evidence of confused judgement. Like the NPD, the Douglas Point reactor was an early prototype in commercial CANDU design. It too has been found to have design inadequacies, and has been allowed to operate by the AECB on condition that it is not operated at full power. Neither reactor has a vacuum building containment system, and neither provides a significant or economic source of electricity for the grid.

To sum up: The Committee report, while it provides a useful account of the findings of many months of work and reflection, and advances a number of constructive proposals for improving the procedures of reactor safety regulation in Ontario, is a report which fails to identify the elements of safety, supply dependence and economic considerations which interrelate in the judgement of "acceptable safety". This failure, in turn, means that the interested public which looks to the report for a clarification of the issues involved in deciding whether Ontario reactors are "acceptably safe" will find the report a confusing document. It offers much less than it should in terms of logical consistency and definition of issues, and it falls regrettably short of reflecting the quality of work which the Committee accomplished as we attempted to answer public questions about the safety of Ontario's reactors.

DISSENT OF THE FOLLOWING MEMBERS:
GEORGE ASHE, ALBERT BELANGER, MICKEY HENNESSY, NICK LELUK AND JOHN WILLIAMS

The above Progressive Conservative members submit the following dissent on the report of the Select Committee's examination of the safety of Ontario's nuclear reactors.

We generally support the Committee's report with the exception of Recommendation X.

> RECOMMENDATION X: THE AECB SHOULD COMMISSION A STUDY TO ANALYZE THE LIKELIHOOD AND CONSEQUENCES OF A CATASTROPHIC ACCIDENT IN A CANDU REACTOR. THE STUDY SHOULD BE DIRECTED BY RECOGNIZED EXPERTS OUTSIDE THE AECB, AECL AND ONTARIO HYDRO. IT SHOUDL BE FUNDED BY A SPECIAL GRANT FROM THE FEDERAL GOVERNMENT. IF THIS STUDY IS NOT COMMISSIONED BY JULY 31, 1980, THE PROVINCE OF ONTARIO SHOULD ENSURE THAT IS IS UNDERTAKEN.

We share the opinion of the majority of Members of the Committee based on the extensive testimony of the expert witnesses who appeared before us, that the nuclear reactors operating in Ontario are "acceptably safe".

We also share, with all Members of the Committee, a wish that every effort be made to ensure that the design, construction and operation of reactors in Ontario be made as safe as is reasonably possible.

In our view, based on the extensive, knowledgeable testimony heard by the Committee, the undertaking of a substantive and expensive study would probably serve little purpose but to identify the fact that a catastrophic type of accident is possible but highly improbable. The results would, as in the Rasmussen study undertaken in the United States, be widely debated and challenged and would in the end serve little practical purpose except to confirm the consensus of this Committee that the reactors are "acceptably safe".

In any event, it is our feeling that further studies deemed necessary by the regulatory authority should be commissioned by that authority. It would in our view be wrong to suggest that the Ontario Government should assume responsibility for a study which is clearly within the proper jurisdiction of the federal government and/or its agency.

During the course of the Committe's hearings, the President of the Atomic Energy Control Board indicated that the Board had recognized the need to study further the possible consequences of severe reactor malfunctions and had already taken steps to evaluate same through studies at Carleton University.

We also heard testimony from Atomic Energy Control Board, Atomic Energy of Canada Limited, Ontario Hydro staff and others, that to undertake an even more comprehensive study, similar to the Rasmussen study in the United States, would likely take a number of years to complete and would represent a very major research undertaking.

In conclusion we do not believe it to be reasonable, or perhaps even practical, to have anyone other than the responsible federal regulatory agency undertake such a study and to assume, thereby, the apparent responsibility for taking any subsequent action on the basis of the results of the study.

The laws of the Government of Canada provide that the AECB be the sole regulatory agency with respect to nuclear reactor safety in Canada.

APPENDIX A

TERMS OF REFERENCE

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On motion by Mr. Welch, seconded by Mr. Kerr,
ORDERED, That a Select Committee of the Legislature be

appointed:

First, to inquire into the cost of construction of the two heavy-water plants being built by Ontario Hydro at the Bruce Nuclear Power Development, and report to the Legislature on all factors affecting cost, such examination to include but not be limited to:

(a) The requirements for heavy water, the original estimates of the cost of the plants and the contract signed with the Lummus Company of Canada for the construction of the plants and the conditions placed on the contracts for Canadian content;

(b) The change in the scope of the work required due to changes in plant design after the original estimates were completed;

(c) The effect on the total cost of the plants and their construction schedule due to the cancellation of the fourth plant known as plant "C";

(d) The factors affecting any additional costs incurred by the contractor and Hydro for the supply of major equipment, structural components or other supply items;

(e) The factors affecting escalation of sub-contracts placed by the contractor, or Hydro for work related to the construction of the plants;

(f) The factor affecting labour costs for construction of the plant including escalation of labour rates, work stoppages, union jurisdictional disputes, and the shortage of any labour skills required for construction;

(g) The effect of interest rates, and foreign exchange rates on the overall costs of construction;

(h) The administration of the contract by Hydro and the control methods used to monitor and minimize the cost, and to prepare and submit a report for the Legislature upon the conclusions of this inquiry.

Second, to review the implementation of the recommendations of the Select Committee of the 30th Parliament which examined Ontario Hydro's proposal for bulk power rate increases for 1976; such review to include consideration of Ontario Hydro's status reports tabled by the Ministry of Energy.

Third, to examine Ontario's nuclear commitment, taking into account the report and recommendations of the Royal Commission on Electrical Power

Planning and Ontario's Energy Future, such examination to include but not be limited to:

(a) Ontario Hydro's system planning strategy for adopting nuclear power and, in particular:

- o Large v. small generating stations;
- o Remote stations v. sites close to urban areas;
- o The ratio of nuclear-fuelled generating stations that should be built in comparison to fossil fuelled stations, keeping in mind security of supply and cost differentials;

(b) The economics of nuclear power v. generation from other primary fuels;

(c) The performance and reliability of nuclear generating stations;

(d) The responsibility for, and the standards relative to the safety of nuclear generation stations;

(e) Environmental impact and health considerations related to nuclear power.

And that the Select Committee may prepare and submit interim reports for the Legislature and shall prepare and submit a final report before the end of December, 1978, and that the Select Committee may request such coverage of its proceedings by Hansard and the printing of such papers as the Committee deems appropriate; and the Committee shall have authority to sit during the interval between sessions and have full power and authority to employ counsel and such other personnel as may be deemed advisable and to call for persons, papers and things, and to examine witnesses under oath and the Assembly doth command and compel attendance before the said Select Committee of such persons and the production of such papers and things as the Committee may deem necessary for any of its proceedings and deliberations, for which the Honourable Speaker may issue his warrant or warrants; and the Committee shall be composed of 14 members as follows: Mr. MacDonald (Chairman), Ashe, Foulds, Gigantes, Haggerty, Handleman, Jones, Kerrio, Lane, Leluk, Nixon, Reed (Halton-Burlington), Samis, and Williams*.

* Messrs. Handleman, Jones, Kerrio, Lane, Samis and Nixon were subsequently replaced by Messrs. Belanger, Cureatz, Conway, Hennessy, Mackenzie and Kerrio.

APPENDIX B

CHRONOLOGY OF THE RECORD OF HEARINGS INTO
THE SAFETY OF NUCLEAR REACTORS IN ONTARIO

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CHRONOLOGY OF THE RECORD OF HEARINGS INTO

THE SAFETY OF NUCLEAR REACTORS IN

ONTARIO

Date of Meeting	Name of Organization and Personnel Representatives
April 19, 1979	**Royal Commission on Electric Power Planning** Porter, Dr. A., Chairman Smith, Ronald, Executive Director Mueller, Mr. Peter, Senior Advisor Choudhury, Mr. Sushil, Researcher
April 20, 1979	**Royal Commission on Electric Power Planning** Porter, Dr. A., Chairman Smith, Ronald, Executive Director Mueller, Mr. Peter, Senior Advisor Choudhury, Mr. Sushil, Researcher
April 25, 1979	**Ministry of Labour** Armstrong, T.E., Deputy Minister Fitch, Dr. Max, Director, Special Studies and Services Branch Aitken, Dr. Harry, Chief, Radiation Protection Services **Atomic Energy Control Board** Jennekens, Jon, President **Ontario Hydro** McConnell, Lorne, General Manager, Operations Morison, W.G., Director, Design and Development Division Woodhead, L.W., Director, Nuclear Generation Division Wilson, R., Director of Health and Safety Watson, D., Manager, Safety Services Department

Date of Meeting	Name of Organization and Personnel Representatives
April 26, 1979	**Ontario Hydro** McConnell, Lorne, General Manager, Operations Morison, W.G., Director, Design and Development Division Woodhead, L.W., Director, Nuclear Generation Division Wilson, R., Director of Health and Safety Watson, D., Manager, Safety Services Department **Ministry of Labour** Fitch, Dr. Max, Director, Special Studies and Services Branch Aitken, Dr. Harry, Chief, Radiation Protection Services **Ontario Provincial Police** Lidstone, J.S., Assistant Commissioner
April 27, 1979	**Ontario Hydro** Watson, D., Manager, Safety Services Department Kelly, R.J., Reactor Safety Engineer, Radioactivity Management and Environmental Protection Department (Member of Ontario Scientific Assessment Team) **Ministry of Labour** Aitken, Dr. J.H., Chief, Radiation Protection Service Fitch, Dr. Max, Director, Special Studies and Services Branch Johnson, Dr. A., Consultant on Energy Research (Member of Ontario Scientific Assessment Team) Wong, Dr. K.Y., Supervisor, Central Health and Safety Division (Member of Ontario Scientific Assessment Team)
May 3, 1979	**Ontario Hydro** McConnell, Lorne, General Manager, Operations Morison, W.G., Director, Design and Development Division

Date of Meeting	Name of Organization and Personnel Representatives
May 3, 1979 (continued)	Woodhead, L.W., Director, Nuclear Generation Division Watson, D., Manager, Safety Services Department Austman, H.L., Station Manager, Bruce "A" Nuclear Generating Station
May 4, 1979	**Ontario Hydro** McConnell, Lorne, General Manager, Operations Morison, W.G., Director, Design and Development Division Woodhead, L.W., Director, Nuclear Generation Division Wilson, R., Director of Health and Safety Watson, D., Manager, Safety Services Department Austman, H.L., Station Manager, Bruce "A" Nuclear Generating Station
May 24, 1979	**Committee Meeting with Staff and Members**
June 15, 1979	**Ontario Hydro** Morison, W.G., Director, Design and Development Division
June 20, 1979	**Ontario Hydro** Morison, W.G., Director, Design and Development Division
July 4, 1979	**Ontario Hydro** Morison, W.G., Director, Design and Development Division Irvine, H.S., Group Manager, Nuclear Design and Development Division
July 5, 1979	**Canadian Coalition for Nuclear Responsibility** Edwards, Dr. G., National Chairman

Date of Meeting	Name of Organization and Personnel Representatives
July 6, 1979	**Atomic Energy Control Board**
	Jennekens, Jon, President Bush, W.R., Manager, Radiation Protection Division
July 9, 1979	**Atomic Energy Control Board**
	Bush, W.R., Manager, Radiation Protection Division
	Atomic Energy of Canada Limited
	Blackstein, F., Assistant to the Vice-President, Chalk River Nuclear Laboratories Myers, Dr., D., Director, Biology Branch, Chalk River Newcombe, Dr. H., Director, Population Research Branch, Chalk River
	Ontario Coalition for Nuclear Responsibility
	Torrie, Mr. R.
July 10, 1979	**University of Pittsburgh, Pittsburgh, Penn.**
	Radford, Dr. E.P., Professor of Environmental Epidemiology, Graduate School of Public Health
	Roswell Park Memorial Institute for Cancer Research Buffalo, N.Y.
	Bross, Dr. I.D.J., Director of Biostatistics
July 11, 1979	**Harvard University, Cambridge, Mass.**
	Rothman, Dr. K. Associate Professor of Epidemiology, School of Public Health
	Ontario Hydro
	Wilson, R., Director, Health and Safety Division

Date of Meeting	Name of Organization and Personnel Representatives
July 12, 1979 (held in Deep River, Ontario)	**Renfrew County Citizens for Nuclear Responsibility**
	Schultz, Mr. N., Counsel Cowan, Mr., Spokesman
	Municipality of Deep River
	Smith, Lyall, Acting Mayor
	Township of Rolph
	Dumanoir, Mr. Guy, Reeve
	Village of Chalk River
	Sequin, Mr. Bob, Reeve
	Townships of Head, Clara, & Maria
	Horricks, Mr. Grant, Reeve
	County of Renfrew
	Sadler, Mr. Jack
	Renfrew County Travel Association
	Hocking, Mr. Brian
	Township of Alice and Fraser
	Donahue, Mr. Al, Clerk-Treasurer
	Serdula Systems
	Serdula, Mr. Kenneth, President
	Deep River Area Business Association
	Fairfield, Mr. Paul

Date of Meeting	Name of Organization and Personnel Representatives
July 12, 1979 (cont'd)	**Society for Professional Employees, Chalk River Laboratories**
	Cassidy, Mr. Richard
	Atomic Energy Allied Council
	St. John, Mr. Clarence, President
	Society for Hydro Management and Professional Staff
	Sutton, Mr. Glenn, Delegate in Rolphton
	Private Citizens
	Mr. Zadow
	Mr. Bob Walker
	Mr. John Snider
	Mrs. Catherine Dalrymple
	Mr. J. Pachner
	Mr. Lionel Ritter
	Mr. E.J. Craig
	Mr. Al Link
	Mr. McLeod
	Mr. Philip Simpson
	Mr. David Wylie
	Mr. Jacques Rubacha
	Mr. Andrew Stirling
	Mr. Ken Burkhart
	Mr. Donald Sutherland
July 13, 1979	**Atomic Energy Control Board**
	Domaratzki, Z., Director, Reactor and Accelerator Branch
	Atomic Energy of Canada Limited
	Axford, D., Head, Reactor Technology Branch
	Morrison, I., Director, Special Projects Division Chalk River Nuclear Laboratories
July 13, 1979	**Ontario Hydro**
	Kelly, R.J., Reactor Safety Engineer, Nuclear Generation Division

Date of Meeting	Name of Organization and Personnel Representatives
July 13, 1979 (cont'd)	Milley, D.C., Station Manager, NPD Generating Station
July 17, 1979	**Atomic Energy of Canada Limited**
	Blackstein, F.P., Assistant to the Vice-President, Chalk River Nuclear Laboratories Krishnan, S., Branch Manager, Safety Branch, Mississauga, Ontario Snell, V., Section Head, Safety Branch, Mississauga, Ontario
	University of Montreal
	Paskievici, Dr. W., Chairman, Interorganizational Working Group
July 18, 1979	**Atomic Energy Control Board**
	Atchison, R.J., Director, Assessment Branch
July 19, 1979	**Atomic Energy of Canada Limited**
	Axford, D., Head, Reactor Technology Branch
	Ontario Hydro
	Kelly, R.J., Reactor Safety Engineer, Nuclear Generation Division Milley, D.C., Station Manager, NPD Generating Station
July 23, 1979	**Carleton University, Ottawa, Ont.**
	Rogers, Dr. J.T.
July 24, 1979	**Atomic Energy Control Board**
	Domaratzki, Z., Director, Reactor and Accelerator Branch

Date of Meeting	Name of Organization and Personnel Representatives
July 25, 1979	**Energy Pathways** Foster, D.
	Canadian Coalition for Nuclear Responsibility Edwards, Dr. G., National Chairman
July 26, 1979	**Ontario Hydro** Irvine, H.S., Group Manager, Nuclear Design and Development Division Morison, W.G., Director, Design and Development Division
July 31, 1979	**Ontario Hydro** McConnell, L.G., Vice-President, Production and Transmission Popple, R.T., Assistant to the Director, Nuclear Generation Division Ryder, J., Station Manager, Pickering Generating Station Woodhead, L., Director, Nuclear Generation Division
August 1, 1979	**Canadian Coalition for Nuclear Responsibility** Edwards, Dr. G., National Chairman
	Private Citizens Mr. G. Newby Mr. W. Taves
August 2, 1979	**Royal Commission on Electric Power Planning** Porter, Dr. A., Chairman Mueller, P.G., Senior Adviser
	University of Toronto, Toronto, Ont. Foley, Dr. P.J., Professor of Industrial Engineering Senders, Dr. J.W., Professor of Industrial Engineering Kaponeridis, A., Human Factors Engineer

Date of Meeting	Name of Organization and Personnel Representatives
August 7, 1979	**Ontario Hydro**
	Kelly, R.J., Reactor Safety Engineer, Nuclear Generation Division
	Owens, A.H., Location Technical Transmission Systems Division
	Ryder, J., Station Manager, Pickering Generating Station
	Woodhead, L., Director, Nuclear Generation Division
August 8, 1979	**Atomic Energy Control Board**
	Domaratzki, Z., Director, Reactor and Accelerator Branch
August 9, 1979	**Ontario Coalition for Nuclear Responsibility**
	Torrie, R.D.
August 14, 1979	**Ontario Hydro**
	Horton, E.P., Operations Manager, Bruce Nuclear Power Development
	Austman, H.L., Station Manager, Bruce Nuclear Power Development
	Ryder, J., Production Manager, Pickering Generating Station
August 15, 1979	**Atomic Energy Control Board**
	Jennekens, Jon, President
	Ministry of Energy & Natural Resources
	Auld, Hon. J.A.C., Minister
August 16, 1979	**Ontario Hydro**
	Macaulay, H.L., Chairman of the Board
September 18, 1979	**The Renfrew County Citizens for Nuclear Responsibility**
	Schultz, N.J., Counsel

Date of Meeting	Name of Organization and Personnel Representatives
September 19, 1979	**Atomic Energy of Canada Limited**
	Morrison, I.W., Director, Special Projects Division
	Axford, D.J., Head, Reactor Technology Branch
	Hancox, W.T., Ph.D., Director, Applied Science Division, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba
	Nieman, Dr. R.W., Head, Thermalhydraulics Research Branch, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba
	Blackstein, F.P., Assistant to the Vice-President, Chalk River Nuclear Laboratories
	Ontario Hydro
	Popple, R.T., Assistant to Director, Nuclear Generation Division
	Kelly, R.J., Reactor Safety Engineer, Nuclear Generation Division
	Milley, D.C., Station Manager, NPD Generating Station
September 20, 1979	**Canatom (Ontario) Limited**
	Siddall, E., President
	Energy Probe
	Rubin, N., Nuclear Power Researcher
September 25, 1979	**Ontario Hydro**
	Morison, W.G., Director Design and Development Division
	Irvine, H.S., Group Manager, Nuclear Design and Development Division
September 26, 1979	**Canadian Coalition for Nuclear Responsibility**
	Edwards, Dr. G., National Chairman
	Federation of Engineering and Scientific Associations
	Bailey, Chris, Executive Member of the Board
	Shalaby, Amin, Executive Member of the Board

Date of Meeting	Name of Organization and Personnel Representatives
September 26, 1979(cont'd)	**Atomic Energy of Canada Limited** Blackstein, F.P., Assistant to the Vice-President Chalk River Nuclear Laboratories
September 27, 1979	**Atomic Energy Control Board** Domaratzki, Z., Director, Reactor and Accelerator Branch Jennekens, Jon, President
October 2, 1979	**Ontario Hydro** Morison, W.G., Director, Design and Development Division Wilson, R., Director, Health and Safety Division Popple, R.T., Assistant to Director, Nuclear Generation Division
October 3, 1979	**Committee Meeting with Staff and Members**
October 4, 1979	**Committee Meeting with Staff and Members**
October 24, 1979	**Committee Meeting with Staff and Members**
November 15, 1979	**Committee Meeting with Staff and Members**
February 12, 1980	**Atomic Energy of Canada Limited** Axford, D., Head, Reactor Technology Branch, Nuclear Laboratories, Chalk River Blackstein, F.P., Assistant to Vice-President, Chalk River Martin, M.P., Manager, Public Information Programs, Corporate Office, Ottawa **Ontario Hydro** Childerhose, Manager, Radioactivity Management and Environmental Protection Department Kelly, R.J., Reactor Safety Engineer, Nuclear Generation Division

Date of Meeting	Name of Organization and Personnel Representatives
February 13, 1980	**Atomic Energy of Canada Limited**
	Gadsby, R.D., Senior Licensing Co-ordinator, Engineering Company, Sheridan Park, Mississauga, Ontario
	Snell, Dr. V., Section Head, Safety Branch, Engineering Company, Sheridan Park, Mississauga, Ontario
	Simmonds, C.A., Senior Project Engineer, Engineering Company, Sheridan Park, Mississauga, Ontario
	Hopwood, J., Section Head, Safety Analysis, Engineering Company, Sheridan Park, Mississauga, Ontario
	Ontario Hydro
	Parry, D.A., Technical Superintendent, Douglas Point
February 14, 1980	**Atomic Energy Control Board**
	Domaratzki, Dr. Z., Director, Reactor and Accelerator Branch
February 19, 1980	**Ontario Hydro**
	Richman, Dr. Jack W., Nuclear Equipment and Processes Engineer, Nuclear Systems Department, Design and Development Division
	Morison, W.G., Director, Design and Development Division
February 20, 1980	**Ontario Hydro**
	Morison, W.G., Director, Design and Development Division
	Kelly, R.J., Reactor Safety Engineer, Nuclear Generation Division
February 26, 1980	**Ontario Hydro**
	Vivian , Gary A., Assessment, Safety and Program Engineer, Nuclear Materials Management Department
	Wilson, R., Director, Health and Safety Division

Date of Meeting	Name of Organization and Personnel Representatives
February 27, 1980	**Canadian Nuclear Association** Ediger, N.M., Immediate Past Chairman, President, Eldorado Nuclear Ltd. Foster, Dr. J.S., First Vice-Chairman, Vice-President, Monenco (Ontario) MacOwan, W., Chairman of the Board, Vice-Chairman, Howden Group Canada Aspin, Dr. Norman, President McNicol, W.J., Director, Vice-President Power Systems Group, Westinghouse Canada Ltd.
February 28, 1980	**Ontario Hýdro** Irvine, H.S., Group Manager, (Nuclear), Design and Development Division
April 10, 1980	**Committee Meeting with Staff and Members**
April 17, 1980	**Committee Meeting with Staff and Members**
May 28, 1980	**Committee Meeting with Staff and Members**
June 4, 1980	**Committee Meeting with Staff and Members**

APPENDIX C

LIST OF WITNESSES APPEARING BEFORE THE SELECT COMMITTEE ON ONTARIO HYDRO AFFAIRS

APPENDIX C

LIST OF WITNESSES APPEARING BEFORE THE SELECT COMMITTEE ON ONTARIO HYDRO AFFAIRS

Government of Ontario

HON J.A.C. AULD	Minister, Ministry of Energy and Natural Resources
T.E. ARMSTRONG	Deputy Minister, Ministry of Labour
DR. MAX FITCH	Director, Special Studies and Sevices Branch Ministry of Labour
DR. HARRY AITKEN	Chief, Radiation Protection Services Ministry of Labour
J.W. LIDSTONE	Assistant Commissioner, Ontario Provincial Police
DR. A. JOHNSON	Ontario Scientific Assessment Team, Ministry of Energy
DR. KAM WONG	Ontario Scientific Assessment Team, Ministry of Labour

Ontario Hydro

H.L. MACAULAY	Chairman of the Board
LORNE McCONNELL	General Manager, Operations Division
W.G. MORISON	Director, Design and Development Division
H.S. IRVINE	Group Manager (Nuclear), Design and Development Division
L.W. WOODHEAD	Director, Nuclear Generation Division
R. WILSON	Director, Health and Safety Division
D. WATSON	Manager, Safety Services Department

Ontario Hydro (continued)

GARY A. VIVIAN	Assessment Safety and Program Engineer, Nuclear Materials Management Department
E.P. HORTON	Operations Manager, Bruce Nuclear Power Development
H.S. AUSTMAN	Station Manager, Bruce "A" Nuclear Generating Station
G. CHILDERHOSE	Manager, Radioactivity Management and Environmental Protection Department
R.J. KELLY	Reactor Safety Engineer, Nuclear Generation Division
D.C. MILLEY	Station Manager, NPD Generating Station
A.H. OWENS	Location Technician, Transmission Systems Division
D.A. PARRY	Technical Superintendent, Douglas Point
R.T. POPPLE	Assistant to the Director, Nuclear Generation Division
DR. JACK W. RICHMAN	Nuclear Equipment and Processes Engineer, Nuclear Systems Department Design and Development Division
J. RYDER	Station Manager, Pickering Generating Station

Atomic Energy of Canada Limited (AECL)

F.P. BLACKSTEIN	Assistant to the Vice-President, Chalk River Nuclear Laboratories
D. AXFORD	Head, Reactor Technology Branch Chalk River Nuclear Laboratories
R.D. GADSBY	Senior Licensing Co-ordinator, Engineering Company, Sheridan Park
DR. W.T. HANCOX	Director, Applied Science Division, Whiteshell Nuclear Research Establishment

Atomic Energy of Canada Limited (AECL) (continued)

J. HOPWOOD	Section Head, Safety Analysis, Engineering Company Sheridan Park
S. KIRSHNAN	Branch Manager, Safety Branch Sheridan Park
M.P. MARTIN	Manager, Public Information Programs Corporate Office
I. MORRISON	Director, Special Projects Division Chalk River Nuclear Laboratories
DR. D. MYERS	Director, Biology Branch Chalk River Nuclear Laboratories
DR. H. NEWCOMBE	Director, Population Research Branch Chalk River Nuclear Laboratories
DR. R.W. NIEMAN	Head, Thermalhydraulics Research Branch Whiteshell Nuclear Research Establishment
D.A. SIMMONDS	Senior Project Engineer Engineering Company Sheridan Park
V. SNELL	Section Head, Safety Branch Engineering Company Sheridan Park

Atomic Energy Control Board (AECB)

JOHN JENNEKENS	President
DR. Z. DOMARATZKI	Director, Reactor and Accelerator Branch
R.J. ATCHISON	Director, Assessment Branch
W.R. BUSH	Manager, Radiation Protection Division

Royal Commission on Electric Power Planning

DR. A. PORTER	Chairman
RONALD SMITH	Executive Director
PETER MUELLER	Senior Advisor
SUSHIL CHOUDHURY	Researcher

Canadian Nuclear Association

W. MacOWAN	Chairman of the Board, (Vice-Chairman, Howden Group Canada)
N.M. EDIGER	Immediate Past Chairman, (President, Eldorado Nuclear Ltd.)
DR. J.S. FOSTER	First Vice-Chairman, (Vice-President, Monenco (Ontario))
W.J. McNICOL	Director, (Vice-President of Power Systems Group for Westinghouse Canada Ltd.)
DR. NORMAN ASPIN	President

Other Witnesses — in alphabetical order

MR. CHRIS BAILEY	Executive Member of the Board, Federation of Engineering and Scientific Associations
DR. I.D.J. BROSS	Director of Biostatistics, Roswell Park Memorial Institute for Cancer Research, Buffalo, New York
MR. RICHARD CASSIDY	Society for Professional Employees, Chalk River Nuclear Laboratories
MR. COWAN	Renfrew County Citizens for Nuclear Responsibility
MR. AL DONAHUE	Clerk-Treasurer, Township of Alice and Fraser
MR. GUY DUMANOIR	Reeve, Township of Rolph

Other Witnesses — in alphabetical order (continued)

DR. GORDON EDWARDS	National Chairman, Canadian Coalition for Nuclear Responsibility
MR. PAUL FAIRFIELD	Spokesman, Deep River Area Business Association
DR. P.J. FOLEY	Professor of Industrial Engineering, University of Toronto
MR. D. FOSTER	Energy Pathways
MR. BRIAN HOCKING	Renfrew County Travel Association
MR. GRANT HORRICKS	Reeve, Village of Chalk River
MR. A. KAPONERIDIS	Human Factors Engineer, University of Toronto
DR. W. PASKIEVICI	Chairman, Interorganizational Working Group, Ecole Polytechnique, University of Montreal
DR. E.P. RADFORD	Professor of Environmental Epidemiology, Graduate School of Public Health University of Pittsburgh, Pittsburgh, Pennsylvania
DR. J.T. ROGERS	Carleton University, Ottawa, Ontario
DR. K. ROTHMAN	Associate Professor of Epidemiology, School of Public Health, Harvard University, Cambridge, Massachusetts
MR. N. RUBIN	Nuclear Power Researcher, Energy Probe
MR. JACK SADLER	Spokesman, County of Renfrew
MR. N. SCHULTZ	Counsel, Renfrew County Citizens for Nuclear Responsibility
MR. BOB SEGUIN	Reeve, Township of Rolph
DR. J.W. SENDERS	Professor of Industrial Engineering, University of Toronto

Other Witnesses — in alphabetical order (continued)

MR. AMIN SHALABY	Executive Member of the Board, Federation of Engineering and Scientific Associations
MR. E. SIDDALL	President, Canatom (Ontario) Limited
MR. LYALL SMITH	Acting Mayor, Municipality of Deep River
MR. CLARENCE ST. JOHN	President, Atomic Energy Allied Council
MR. GLEN SUTTON	Delegate in Rolphton, Society for Hydro Management and Professional Staff
MR. R. TORRIE	Ontario Coalition for Nuclear Responsibility

Private Citizens Appearing as Witnesses — in alphabetical order

MR. KEN BURKHART

MR. E.J. CRAIG

MRS. CATHERINE DALRYMPLE

MR. AL LINK

MR. McLEOD

MR. G. NEWBY

MR. J. PACHNER

MR. LIONEL RITTER

MR. JACQUES RUBACHA

MR. KENNETH SERDULA

MR. PHILIP SIMPSON

MR. JOHN SNIDER

MR. ANDREW STIRLING

MR. DONALD SUTHERLAND

MR. W. TAVES

Private Citizens Appearing as Witnesses — in alphabetical order (continued)

MR. BOB WALKER

MR. DAVID WYLIE

MR. ZADOW

APPENDIX D

LIST OF EXHIBITS TABLED IN MEETINGS FROM APRIL 25,1979
TO APRIL 10,1980

APPENDIX D

LIST OF EXHIBITS TABLED IN MEETINGS FROM APRIL 25, 1979 to APRIL 10, 1980

Exhibit #	Title	Date Tabled
E-1	Presentation to The Select Committee of the Ontario Legislature on Nuclear Safety & Emergency Procedures for Nuclear Generation Stations.	April 25, 1979
E-2	AECB -- 1139 -- The Licensing Process for Nuclear Power Reactors, by M. Joyce, Atomic Energy Control Board, Ottawa.	April 25, 1979
E-3	Letter dated April 17, 1979 from Thomas L. Wells, Minister, Ministry of Intergovernmental Affairs to The Honourable Don Jamieson, Re: Accident at Three Mile Island Plant at Middletown, Pennsylvania.	April 25, 1979
E-4	Presentation to The Select Committee on Ontario Hydro Affairs concerning Off-Site Contingency Plans.	April 26, 1979
E-5	Notice to public from Medical Officer of Health Regional Municipality of Durham and Chief Physician/Manager Health Services, Ontario Hydro, Re: Radioactive material in air.	April 26, 1979
E-6	Statement by Leader of the Opposition, to Hydro Affairs Committee, Re: Nuclear Reactor Safety.	April 27, 1979
E-7	Ontario Hydro 1979 Review of Generation Expansion Program	April 27, 1979
E-7A	Supplement to 1979 Review of Generation Expansion Program Comparison of the Recommended Alternative with Alternatives 3 and 5	April 27, 1979

Exhibit #	Title	Date Tabled
E-8	Report of The Scientific Assessment Team to the Ontario Interministerial Agency Coordinating Committee, Re: Three Mile Island Nuclear Generating Station Accident of March 28, 1979.	April 27, 1979
E-9	Presentation to The Select Committee of the Ontario Legislature on Nuclear Safety & Emergency Procedures for Nuclear Generating Stations.	May 4, 1979
E-10	Reporting of Abnormal Events Dated, May 4, 1979	May 23, 1979
E-11	Royal Commission on Environmental Pollution. Chairman, Sir Brian Flowers. Sixth Report. Nuclear Power and the Environment. Presented to Parliament by Command of Her Majesty, September 1978.	May 23, 1979
E-11A	Nuclear Power and the Environment. The Government's Response to the Sixth Report of the Royal Commission on Environmental Pollution (Comnd). Presented to Parliament by the Secretary of State for the Environment by Command of Her Majesty, May 1977.	May 23, 1979
E-12	The Cluff Lake Board of Inquiry Final Report, May 31, 1978.	May 23, 1979
E-12A	The Saskatchewan Government Response to The Cluff Lake Board of Inquiry Report, June 1978.	May 23, 1979
E-13	Summary Argument to the Royal Commission on Electric Power Planning (Porter Commission), by Ralph Torrie and Gordon Edwards, Canadian Coalition on Nuclear Responsibility, 2030 Mackay, Montreal, 1978.	May 23, 1979

Exhibit #	Title	Date Tabled
E-14	The Atomic Energy Control Board In the Matter of the Atomic Energy Control Act, R.S.C. 1970 c. A-19. In the Matter of an Application by James Croy, Valerie Croy, Charles Myers, Sharon Myers, Henry Venema, Mary Anne Venema, and The Renfrew County Citizens for Nuclear Responsibility for a Public Hearing into the Safety of the Nuclear Reactor at Rolphton on the Ottawa River in the County of Renfrew.	May 23, 1979
E-15	Letter dated June 20, 1979 From Robert B. Taylor, Chairman and Hugh L. Macaulay, Vice Chairman to Donald MacDonald, Chairman, Ontario Select Committee on Hydro Affairs, Re: Controlled access to nuclear safety documents.	June 20, 1979
E-16	Letter dated June 27, 1979 From N.J. Schultz, Counsel for the Renfrew County Citizens for Nuclear Responsibility to Donald MacDonald, Chairman, Select Committee on Ontario Hydro Affairs Re: Nuclear Reactor Safety.	July 4, 1979
E-17	Letter from J.E. Wilson, Public Hearings Officer, Public Hearings Department to Donald MacDonald, Chairman, Select Committee on Ontario Hydro Affairs, Re: Attached list of information forwarded to Legislative Library.	July 4, 1979
E-17A	Reports requested by the Select Committee on Ontario Hydro Affairs, Re: Controlled Access.	July 10, 1979
E-17B	Reports requested by the Select Committee on Ontario Hydro Affairs, Re: No Restriction.	July 10, 1979

Exhibit #	Title	Date Tabled
E-17C	Letter dated August 3, 1979 from J.E. Wilson, Public Hearings Officer, Ontario Hydro to Donald MacDonald, MPP, Chairman, Select Committee on Ontario Hydro Affairs, Re: Documents forwarded to Legislative Library.	August 7, 1979
E-18	Select Committee on Ontario Hydro Affairs. Examination of Ontario's Nuclear Commitment -- Staff Introduction to Summer Hearing into The Safety of Ontario Reactors, July 4, 1979.	July 4, 1979
E-19	Presentation to The Select Committee of the Ontario Legislature on Nuclear Power, July 1979, Re: Introduction, Safety Philosophy and Criteria, Design, Licensing, Operation, Safety Administration and Control, Summary and Conclusions	July 4, 1979
E-20A	"Do Nuclear Engineering Educators have a Special Responsibility?". Alvin M. Weinberg, Institute for Energy Analysis, Oak Ridge Associated Universities, Oak Ridge, Tennessee, U.S.A.	July 5, 1979
E-20B	Canadian Coalition for Nuclear Responsibility Excerpts from Estimating Lung Cancers or, "It's Perfectly Safe, But Don't Breathe Too Deeply" Summary presented by Gordon Edwards, to Elliott Lake Environmental Assessment Board, March 1978 (revised May, 1978)	July 5, 1979
E-20C	Letter dated February 2, 1979, from Victor E. Archer, M.D., Medical Director, Department of Health, Education, and Welfare, Public Health Service, Health Services and Mental Health Administration, Salt Lake City, Utah, to Mr. Frank Palmay, Re: Risk Estimates.	July 5, 1979

Exhibit #	Title	Date Tabled
E-20D	Letter dated March 2, 1979, from Gordon Edwards, Canadian Coalition for Nuclear Responsibility, to Mr. P.J. Dyne, Director, Office of Energy Research and Development, Ottawa, Re: Reactor Grade Plutonium for Bombs	July 5, 1979
E-20E	Could Britain be Energy Self-Sufficient by 2000? New Report Stresses Efficiency Gains, Better Forecasting, Reduced Nuclear.	July 5, 1979
E-20F	Letter dated March 6, 1979, from Gordon Edwards, Canadian Coalition for Nuclear Responsibility to Mr. Jon Jennekins, President, Atomic Energy Control Board (AECB), Ottawa.	July 5, 1979
E-20G	Letter dated January 13, 1979, from Gordon Edwards, Canadian Coalition for Nuclear Responsibility to Bob Blackburn, Secretary, Atomic Energy Control Board (AECB), Ottawa, Re: CANDU Safety and Canadian Radiation Standards.	July 5, 1979
E-20H	Article from The Sunday Times, London, Re: Nuclear plant in 'Quake Zone' Act of Madness - -Geologist says.	July 5, 1979
E-20I	News Article, Re: Quebec's Reactor: How Safe Is It? Plant Having problems says Hydro Engineer.	July 5, 1979
E-20J	The Incident at Browns Ferry --Alabama's Nightmare in Candlelight, by David Dinsmore Comey.	July 5, 1979
E-20K	Press Release and background information for April 3, 1979, Canadian Coalition for Nuclear Responsibility Re: The Harrisburg Nuclear Accident Could Happen Here.	July 5, 1979
E-21	Nuclear Safety or Nuclear Unsafety? -- The Limits to Prediction and Control. Outline for presentation of Dr. Gordon Edwards.	July 5, 1979

Exhibit #	Title	Date Tabled
E-22	Introductory Statement to Select Committee on Ontario Hydro Affairs, by Jon. H.F. Jennekens, President, Atomic Energy Control Board, (AECB), Ottawa, July 6, 1979.	July 6, 1979
E-23	Atomic Energy Control Board -- Annual Report 1977-78.	July 6, 1979
E-24	Basis for Limiting Exposure to Ionizing Radiation. Presented to The Select Committee on Ontario Hydro, Toronto, July 6, 1979, by W.R. Bush, Manager, Radiation Protection Division, Atomic Energy Control Board.	July 9, 1979
E-25	Memorandum dated December 5, 1978, from W.R. Bush, to J.H. Jennekens, Re: New Environmental Radiation Protection Standards for Nuclear Power Operations in the U.S.A. (25 mrem)	July 9, 1979
E-26	Published Estimates of Health Risks from Coal and from Nuclear Energy (data cited from Newcombe, 1977 and Myers & Newcombe 1978).	July 9, 1979
E-26A	Curriculum Vitae--Howard B. Newcombe.	July 9, 1979
E-26B	Curriculum Vitae--David K. Myers.	July 9, 1979
E-27	Letter dated June 28, 1979 to the Clerk of the Legislature, from D.B. Kelly, Deputy City Clerk, City of Sarnia, Re: Atomic Energy Control Board -- Recent Accidents at Douglas Point Nuclear Station.	July 10, 1979
E-28	Testimony before The Select Committee on Ontario Hydro Affairs, July 10, 1979, by Edward P.Radford, M.E., Professor of Environmental Epidemiology, Graduate School of Public Health, University of Pittsburgh.	July 10, 1979

Exhibit #	Title	Date Tabled
E-29	A Reassessment of the Health Hazards of Low-Level Ionizing Radiation: The Limiting Factor in the Nuclear Power Cycle, by Irwin D.J. Bross, PhD, Director of Biostatistics, Roswell Park Memorial Institute, Buffalo, New York.	July 10, 1979
E-30	Review of Dr. Irwin Bross' Presentation on Radiation Exposure and Cancer Risk, Kenneth J. Rathman, April 7, 1978.	July 11, 1979
E-31	Presentation to The Select Committee of the Ontario Legislature on Safety and Nuclear Power by Ontario Hydro.	July 11, 1979
E-32	Submission of the Renfrew County Citizens for Nuclear Responsibility on the Nuclear Power Demonstration Generating Station at Rolphton on the Ottawa River in the County of Renfrew.	July 13, 1979
E-33	Magazine article. "Low Level Radiation: A High-Level Concern".	July 13, 1979
E-34	"Risk Assessment Review Group Report to the Nuclear Regulatory Commission". Prepared for U.S. Nuclear Regulatory Commission.	July 13, 1979
E-35	Press release from A.E.C.B. Dated June 1, 1979, Re: Statement on Application for Hearing re: N.P.D. Nuclear Generating Station.	July 13, 1979
E-36	Presentation by Ontario Hydro and A.E.C.L. to the Select Committee on Hydro Affairs regarding the NPD (Nuclear Power Demonstration) Nuclear Generating Station, July 13, 1979	July 13, 1979
E-37	IJW - CV2 Valve Failure at NPD	July 13, 1979
E-38	Introductory remarks, by Dr. W. Paskievici before The Select Committee on Ontario Hydro Affairs.	July 17, 1979

Exhibit #	Title	Date Tabled
E-39	Report of the Interagency Task Force on the Health Effects of Ionizing Radiation, June 1979.	July 17, 1979
E-39A	Interagency Task Force on the Health Effects of Ionizing Radiation: Report of the Work Group on Science, June 1979.	July 17, 1979
E-39B	Interagency Task Force on Health Effects of Ionizing Radiation: Report of the Work Group on Records and Privacy, June 1979.	July 17, 1979
E-39C	Interagency Task Force on the Health Effects of Ionizing Radiation: Report of the Work Group on Care and Benefits, June 1979.	July 17, 1979
E-39D	Interagency Task Force on the Health Effects of Ionizing Radiation: Report of the Work Group on Exposure Reduction, June 1979.	July 17, 1979
E-39E	Interagency Task Force on the Health Effects of Ionizing Radiation: Report of the Work Group on Public Information, June 1979.	July 17, 1979
E-39F	Interagency Task Force on the Health Effects of Ionizing Radiation: Report of Institutional Arrangements, June 1979.	July 17, 1979
E-39G	Interagency Task Force on the Health Effects of Ionizing Radiation: Public comments on the Work Group Reports, June 1979.	July 17, 1979
E-40	Briefs presented to Committee at Rolphton. Meeting, July 12, 1979.	July 17, 1979
E-41	Petition: We, the undersigned living in the immediate vicinity of the Nuclear Power Demonstration (N.P.D.), wish to record our confidence in the overall operation. For seventeen years it has made a major contribution to both our electrical supply and training of staff: it has done so with no injury to any member of the public.	July 17, 1979

Exhibit #	Title	Date Tabled
E-42	Cancer and low level ionizing radiation. Karl Z. Morgan. The Bulletin, 1978.	July 17, 1979
E-43	Memo to Select Committee on Hydro Affairs from D.K. Myers, Head, Biology Branch, Chalk River Nuclear Laboratories, July 11, 1979.	July 17, 1979
E-44	Abstract Discussions of early safety considerations	July 17, 1979
E-45	Transparencies (copies) re: presentation by Dr. Snell, AECL.	July 17, 1979
E-46	International Atomic Energy Agency Safety Standards.	July 17, 1979
E-47	Safety of CANDU Nuclear Power Stations by V.G. Snell.	July 17, 1979
E-48	CANDU Reactor Safety Design Proceedings of a symposium. Canadian Nuclear Association. November 1978.	July 17, 1979
E-49	Nuclear Reactor Philosophy and Criteria presented on July 18, 1979 to the Select Committee on Ontario Hydro Affairs Summer Schedule on the Safety of Nuclear Reactors, Session 3, July 17-19, 1979. AECB Participant - R.J. Atchison, Director, Assessment Branch, Atomic Energy Control Board	July 18, 1979
E-50	Letter from the Public Interest Advocacy Centre, dated July 17, 1979 to Donald MacDonald, M.P.P., Chairman, Select Committee on Hydro Affairs Re: Derived Release Limits for NPD Reactor.	July 19, 1979
E-51	Letter dated June 5, 1979 from J.F.D. MacIsaac, Q.C., Director of Legal Services, Atomic Energy Control Board to N.J. Schultz, Counsel for the Renfrew County Citizens for Nuclear Responsibility Re: question of disclosure of information respecting atomic energy.	July 23, 1979

Exhibit #	Title	Date Tabled
E-51-A	Letter dated July 20, 1979 from N.J. Schultz, Counsel for the Renfrew County Citizens for Nuclear Responsibility to Z. Domaratzki, Director, Reactor and Accelerator Branch, Atomic Energy Control Board Re: file 21-5-10.	July 23, 1979
E-51-B	Letter dated July 20, 1979 from N.J. Schultz, Counsel for the Renfrew County Citizens for Nuclear Responsibility to Donald MacDonald, M.P.P., Chairman, Select Committee on Ontario Hydro Affairs, re: NPD Reactor.	July 23, 1979
E-52	CANDU Moderator Provides Ultimate Heat Sink in a LOCA by J.T. Rogers. Paper Published in Nuclear Engineering International, January 1979.	July 23, 1979
E-52-A	Figures to accompany testimony of J.T. Rogers to Select Committee, July 23, 1979.	August 15, 1979
E-53	No Significnt Fuel Failures (NSFF). Presented to the Ontario Select Committee on Hydro Affairs by Z. Domaratzki, Atomic Energy Control Board.	July 24, 1979
E-54	Brief by Ronald S. Davis, Deep River, Ontario.	July 24, 1979
E-54-A	Letter dated July 30, 1979 from Ronald S. Davis to Donald MacDonald, M.P.P., Chairman, Select Committee on Hydro Affairs, Re: Responses to Mr. Schultz's comment of July 25, 1979.	August 7, 1979
E-55	Letter dated July 18, 1979 to Select Committee on Hydro Affairs from Henry V. Brown, Mayor, City of Pembroke.	July 24, 1979

Exhibit #	Title	Date Tabled
E-56	Canadian Nuclear Association, Nineteenth Annual International Conference, Toronto, Canada, June 10-13, 1979 - President's Address, CNA Committee Reports.	July 25, 1979
E-56-A	Canadian Nuclear Association, Nineteenth Annual International Conference, Toronto, Canada, June 10-13, 1979 - Proceedings.	July 25, 1979
E-57	Radiation Protection Training, Health and Safety Division, Ontario Hydro, 481.1 Course 3 Revised 1978.	July 25, 1979
E-58	Radiation Protection Training, Health and Safety Division, Ontario Hydro, 481.2 Revised 1978.	July 25, 1979
E-59	Rasmussen's Numbers Game, Taken from Nuclear Power - The Unviable Option by John J. Berger. Pages 58-59 Inc.	July 25, 1979
E-59-A	Program Outline, Energy Pathways Policy Research Group.	July 25, 1979
E-59-B	Program and Policy Outline on Nuclear Waste Management in Canada, Energy Pathways, Killaloe, Ontario.	July 25, 1979
E-60	Risk Assessment and Public Confidence. An outline of testimony by Dr. Gordon Edwards to the Select Committee on Ontario Hydro Affairs, July 25, 1979.	July 25, 1979
E-60-A	Curriculum Vitae. Dr. Gordon Edwards.	July 25, 1979
E-60-B	Excerpts from the testimony of Mr. Liberty Pease, Manager, Safety Analysis Division, Power Projects (AECL), to the Porter Commission (July 12-13, 1977)	July 25, 1979
E-60-C	Nuclear Fuel Melting as seen by The Rasmussen Report (WASH-1400) with some additional comments re the CANDU Reactor.	July 25, 1979

Exhibit #	Title	Date Tabled
E-60-D	Excerpts from the book "The Accident Hazard of Nuclear Power Plants" by Richard E. Webb, University of Massachusetts Press, 1976.	July 25, 1979
E-60-E	Untersuchungen Zum Vergleich Grosstmoglicher Storfallfolgen In Einer Wiederaufarbeitungsanlage Und In Einem Kernkraftwerk Dr. D. Bachner, D. Holm, A. Meltzer, G. Morlock, Dr. P. NeuBer und Dr. H. Urbahn	July 25, 1979
E-60-F	Letter from the Comptroller General of the United States to the Honourable Mike Gravel, United States Senate.	July 25, 1979
E-60-G	Letter from R.W. Blackburn, Atomic Energy Control Board dated May 11, 1979 to Dr. Gordon Edwards.	July 25, 1979
E-60-H	Unedited Transcript of Testimony of Dr. William Bryan before Sub-committee on State Energy Policy, Committee on Planning, Land Use and Energy - California State Assembly - Hon. Charles Warren, Subcommittee Chairman, February 1, 1974.	July 25, 1979
E-60-I	Health Physics, Volume 33, No.3 September 1977.	July 25, 1979
E-60-J	Conference on Faith, Science, and the Future. July 12-24, 1979, Cambridge, Massachusetts. Document#23.	July 25, 1979
E-61	Week 3 - Design 1. Derivation of Design Basis Release Limits 2. Defence-in-Depth Approach (Ontario Hydro).	July 26, 1979
E-62	Week 4 - Licensing (Ontario Hydro).	July 26, 1979
E-62-A	Condition: Normal Operation Fuel. Cooling: PHT Coolant Circulation.	August 7, 1979

Exhibit #	Title	Date Tabled
E-63	The Need for a Cost-Benefit Perspective in Nuclear Regulatory Policy by Edward P. O'Donnell, Chief Nuclear Licensing Engineer, Ebasco Services Incorporated.	July 26, 1979
E-64	Operation of Nuclear Stations prepared by Ontario Hydro.	July 31, 1979
E-65	Letter dated July 25, 1979 from R.W. Blackburn, A.E.C.B. to W.E. Raney, Q.C., Secretary and General Counsel, Ontario Hydro re: certain documents requested by Select Committee.	July 31, 1979
E-66	Letter dated July 31, 1979 from Tilley, Carson & Findlay to Alan M. Schwartz re: Select Committee on Hydro Affairs Request for Correspondence.	July 31, 1979
E-67	Pickering G.S.A., LOCA Reanalysis Correspondence.	July 31, 1979
E-68	Preliminary Evaluation of the Safety Features of Pickering N.G.S. - "A" Relative to the Three Mile Island Accident.	July 31, 1979
E-68-A	Preliminary Evaluation of the Safety Features of Pickering G.S. "B" Relative to the Three Mile Island Accident.	July 31, 1979
E-68-B	Preliminary Evaluation of the Safety Features of Bruce N.G.S "A" Relative to the Three Mile Island Accident.	July 31, 1979
E-68-C	Preliminary Evaluation of the Safety Features of Bruce N.G.S "B" Relative to the Three Mile Island Accident.	July 31, 1979
E-68-D	Atomic Energy of Canada Limited, Engineering Company, Sheridan Park, Mississauga, Preliminary Evaluation of the Safety Features of Douglas Point G.S. Relative to the Three Mile Island Accident 1979 April 12.	July 31, 1979

Exhibit #	Title	Date Tabled
E-68-E	Preliminary Evaluation of the Safety Features of N.P.D. Relative to the Three Mile Island Accident.	July 31, 1979
E-68-F	News Release: Atomic Energy Control Board May 23, 1979. A.E.C.B. Completes Preliminary Staff Assessment of CANDU Design Review Relative to U.S. Nuclear Reactor Accident.	July 31, 1979
E-69	Opening Statement by Mr. L.G. McConnell, July 31, 1979.	July 31, 1979
E-70	Statement to the Select Committee on Ontario Hydro Affairs by Gordon Edwards, Chairman of the Canadian Coalition for Nuclear responsibility	August 1, 1979
E-70-A	Quotations about Nuclear Energy.	August 1, 1979
E-70-B	Nuclear Power: The Canadian Issues. A Submission from Atomic Energy of Canada Limited to the Royal Commission on Electric Power Planning in response to the Commission's Issue paper No.1 "Nuclear Power in Ontario".	August 1, 1979
E-70-C	Correspondence between Alastair Gillespie and Gordon Edwards on the subject of CANDU Nuclear Safety, April 1979.	August 1, 1979
E-70-D	Excerpt from WASH-1400, Appendix VII, Pages 6 & 7.	August 1, 1979
E-70-E	Canadian Coalition for Nuclear Responsibility. Excerpt from the Burns Report (New Zealand) March 1977.	August 1, 1979
E-70-F	Investigations to Compare Maximum Possible Consequences of Accidents in a Reprocessing Plant and in a Nuclear Power Plant. An English precis by G. Edwards of the German Study entitled Untersuchungen Zum Vergleich Grosstmoglicher Storfallfolgen In Einer Wiederaufarbeitungsanlage Und In Einem Kernkraftwerk by Dr. D. Bachner, D. Holm, A. Meltzer, G. Morlock, Dr. P. Neusser, and Dr. H. Urbahn, of the Institute for Reactor Safety, Federal Republic of Germany - August 1976.	August 1, 1979

Exhibit #	Title	Date Tabled
E-70-G	"Three Mile Island - Four Months Later". Item from Business Week, July 30, 1979.	August 1, 1979
E-70-H	Figure 10: A destructive nuclear runaway (power excursion) test conducted in 1954 of a small nuclear reactor.	August 1, 1979
E-70-I	Text of anonymous letter on the Rolphton Plant received by M. Bein.	August 1, 1979
E-70-J	World Council of Churches, Conference on Faith, Science, and the Future July 12-24, 1979. Resolution on Disarmament.	August 1, 1979
E-70-K	Canadian Coalition for Nuclear Responsibility. Radiation Exposures to Cargo Handlers at Dorval Airport.	August 1, 1979
E-70-L	Exchange of Correspondence between an Ottawa Doctor and The Atomic Energy Control Board - Re: Inadequate Containment of Low Level Radioactive Waste near an Ottawa Suburban Community - April 1977.	August 1, 1979
E-70-M	Radiation and Man.	August 1, 1979
E-71	Letter dated June 15, 1979 from T.J. Molloy, Manager, Power Reactor Division, Atomic Energy Control Board to L.W. Woodhead, Director, Nuclear Generation Division, Ontario Hydro Re: Safety System Availability at Operating Stations.	August 2, 1979
E-72	Letter dated July 31, 1979 from L.W. Woodhead, Director of Nuclear Generation, Ontario Hydro to T.J. Molloy, Manager, Power Reactor Division, A.E.C.B. Operations Directorate Re: Safety System Availability at Operating Stations.	August 2, 1979

Exhibit #	Title	Date Tabled
E-73	Royal Commission on Electric Power Power Planning "Human Factors in Power Plant Design, Operation, and Safety" by John W. Senders, Patrick J. Foley, Consultants, September 1978.	August 2, 1979
E-74	Letter to Alan Schwartz, Committee Counsel, from J.E. Wilson, Public Hearings Department, Ontario Hydro Re: Ontario Hydro Mortality Studies.	August 7, 1979
E-75	Letter to Alan Schwartz, Committee Counsel, from J.E. Wilson, Public Hearings Department, Ontario Hydro Re: Questions Raised in Dr. Radford's Testimony in Regard to Tritium Releases and Their Effect on Female Oocytes.	August 7, 1979
E-76	Letter to Donald MacDonald, M.P.P., Chairman of the Select Committee on Ontario Hydro Affairs, from Nikol James Schultz, Counsel for the Renfrew County Citizens for Nuclear Responsibility, Re: Reactor Safety Inquiry.	August 7, 1979
E-77	The process of Risk Assessment in National, Provincial and Local Policy Decisions on Nuclear Power, AECB-1127 Report prepared by Ian Burton and Anne Whyte, Institute for Environmental Studies, University of Toronto, November 25, 1977.	August 7, 1979
E-77-A	Environmental and Health Effects of Fossil Fuel and Nuclear Power Generation, by Syed J. Naqvi, D. Bruce Black and Colin R. Phillips, Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario.	August 7, 1979
E-77-B	"An Approach for Determining the Acceptable Levels of Nuclear Risk" AECB-1130, Report Prepared for the Directorate of Research and Coordination, Atomic Energy Control Board by the Bureau of Management Consulting, AECB Project 34-0-2-0, BMC Project 3-1994, March 1978.	August 7, 1979

Exhibit #	Title	Date Tabled
E-77-C	Evaluation of Report AECB-1119, Risk of Energy Production AECB-1131, by Lemberg Consultants Ltd.	August 7, 1979
E-77-D	Material Irradiation and Down Syndrome: A Study Based on Record Linkage. D.L. Gibson, S.H. Uh, and J.R. Miller, April 1978.	August 7, 1979
E-78	Population Doses and Health Consequences following a Nuclear Accident. Excerpts from WASH-1400 -Appendix VI.	August 7, 1979
E-78-A	An Epidemiological Evaluation of Health Effects in a General Population Residing in an Area Contaminated with Plutonium: A Preliminary Report by Carl J. Johnson, M.D., M.P.H.	August 7, 1979
E-78-B	The Zirconium Connection by Daniel M. Pisello, 1979.	August 7, 1979
E-79	Operation of Nuclear Stations, Ontario Hydro.	August 7, 1979
E-80	Response of Ontario Hydro and Atomic Energy of Canada Limited, joint licensees, to the submissions of the Renfrew County Citizens for Nuclear Responsibility with respect to the safety of the Nuclear Power Demonstration Generating Station August 7, 1979.	August 7, 1979
E-81	AECB Compliance Procedures for Nuclear Power Plants by Z. Domaratzki, Atomic Energy Control Board, August 8, 1979.	August 8, 1979
E-82	Notes for Testimony of Ralph D. Torrie, August 9, 1979.	August 9, 1979
E-82-A	Referenced Version of Exhibit E-82 by Ralph Torrie.	September 19, 1979
E-82-B	Letter dated August 16, 1979 from Ralph Torrie to James Fisher, Consultant, Select Committee on Ontario Hydro Affairs - Re: Pickering N.G.S. "A" ECCS unavailability.	September 27, 1979

Exhibit #	Title	Date Tabled
E-83	Letter dated August 3, 1979 from J.E. Wilson, Public Hearings Officer, to Alan M. Schwartz, Committee Counsel, Re: Clarification of statement cited by Dr. Gordon Edwards.	August 14, 1979
E-84	Declaration by Patrick D. O'Brien, Re: Bruce G.S. "A".	August 14, 1979
E-85	Review of Twelve Selected Abnormal Event Reports, August 14, 1979.	August 14, 1979
E-86	"I was the only victim of Three-Mile Island" by Dr. Edward Teller.	August 15, 1979
E-87	Closing statement to the Select Committee of the Ontario Legislature on Ontario Hydro Affairs by J.H.F. Jennekens, President, Atomic Energy Control Board, Ottawa, Canada. August 15, 1979.	August 15, 1979
E-88	Nuclear Power Reactor Safety in Illinois. A Report to the Honourable James Thomson, Governor of the State of Illinois. By the Ad-Hoc Nuclear Power Reactor Safety Review Committee, Illinois Commission on Atomic Energy. July 1979.	August 15, 1979
E-89	Press Release dated September 18, 1979 from Ontario Hydro: "NPD Repairs Completed".	September 18, 1979
E-90	The Legislative Assembly of Ontario "Reply Submissions of the Renfrew County Citizens for Nuclear responsibility with Respect to the Safety of the Nuclear Power Demonstration Generating Station at Rolphton on the Ottawa River in the County of Renfrew", dated August 21, 1979.	September 18, 1979
E-90-A	"Short Summary of the Position of the Renfrew County Citizens for Nuclear Responsibility."	September 18, 1979

Exhibit #	Title	Date Tabled
E-91	"Coming to Some Conclusions on Nuclear Safety". Schedule for Last Three Weeks on the Summer Hearings of the Select Committee on Hydro Affairs, September 18, 1979.	September 18, 1979
E-92	Letter dated August 20, 1979 to Mr. Donald MacDonald, M.P.P., Chairman, Select Committee on Hydro Affairs, from Hugh L. Macaulay, Chairman of the Board, Ontario Hydro, re: Globe and Mail article on interview with Jon Jennekens, President A.E.C.L.	September 19, 1979
E-93	The Perils of Probabilities Energy Probe's response to AECB-1149, "Proposed Safety Requirements for Licensing of CANDU Nuclear Power Plants" (IOWG Report). A brief to the Atomic Energy Control Board by Norman Rubin, September 1979.	September 19, 1979
E-94	A.E.C.L. Description of Dispersion of Radioactive Emissions from N.P.D. presented by Mr. Blackstein, September 19, 1979.	September 19, 1979
E-95	Report - Nuclear Safety in Perspective, E.S. Siddall, Canatom, Canada.	September 19, 1979
E-96	Ontario Hydro Appearance, September 19, 1979, Nuclear Power Demonstration Reactor.	September 19, 1979
E-97	Ontario Hydro/A.E.C.L., Position on N.P.D.G.S. with respect to Select Committee on Hydro Affairs.	September 19, 1979
E-98	Letter dated September 25, 1979 from J. E. Wilson, P.Eng., Public Hearings Officer, Public Hearings Department, Ontario Hydro, to Alan Schwartz, Committee Counsel, re: information promised by Mr. R. Wilson before Select Committee on July 11, 1979.	September 25, 1979

Exhibit #	Title	Date Tabled
E-99	Table 1, Sample of Accident Analysis Results, Comparisons of Pickering and Bruce.	September 25, 1979
E-100	Cosmetic Solutions are Not Enough, G. Edwards, September 26, 1979.	September 26, 1979
E-100-A	Energy Policy and Public Acceptance Lecture given at the IAEA Conference in Saltzburg, Austria, May 9, 1977 by Hannes Alfven, Nobel Laureate in Physics, 1979.	September 26, 1979
E-100-B	"What is Radiation?" Ontario Hydro.	September 26, 1979
E-100-C	C.C.N.R. Transitions, Reprinted, 1979.	September 26, 1979
E-100-D	Estimating Lung Cancers or "It's Perfectly Safe, But Don't Breathe Too Deeply" A summary of testimony presented by Gordon Edwards to the Elliott Lake Environmental Assessment Board dealing with the problem of radon gas in buildings, March 1978. (see Exhibit E-20-B, Tabled, July 5, 1979)	September 26, 1979
E-100-E	"Step out of the Nuclear Shadow", C.C.N.R. Newsletter, September-October, 1979. C.C.N.R. Transitions.	September 26, 1979
E-101	CANDU Reactor Safety Research Program, Atomic Energy of Canada Ltd. Whiteshell Nuclear Research Establishment, Pinawa, Manitoba.	September 27, 1979
E-102	"Rating the Risks" by Paul Slovic, Buruch Fischhoff and Sarah Lichtenstein	September 27, 1979
E-103	Letter dated May 17, 1979 (with attachments) from Roger J. Mattson, Director, Division of Systems Safety Office of Nuclear Reactor Regulations United States Nuclear Regulatory Commission, Washington, D.C. to Evelyn Gigantes, M.P.P. Re: "Post-Accident Hydrogen Production in Nuclear Power Plants".	October 2, 1979

Exhibit #	Title	Date Tabled
E-104	Renewable Energy in Developing Countries - An Overview by Ralph Torrie and Miles Goldstick, March 1979.	October 2, 1979
E-105	Browns Ferry - The Regulatory Failure -Daniel F. Ford, Henry E. Kendall, Lawrence S. Tye, Union of Concerned Scientists, Cambridge, Mass. June 10, 1976.	October 2, 1979
E-106	United States of America Before the Nuclear Regulatory Commission - Union of Concerned Scientists' Petition for Emergency and Remedial Action.	September 27, 1979
E-107	Submission to the Select Committee on Ontario Hydro Affairs by the Federation of Engineering and Scientific Associations (FESA), September 26, 1979.	September 26, 1979
E-108	Letter dated September 25, 1979 from Z. Domaratzki, Director, Reactor and Accelerator Branch, Atomic Energy Control Board to Mr. A. Schwartz, Committee Counsel Re: Mr. Domaratzki's response to actions placed on him at previous appearances before the Committee.	September 27, 1979
E-109	Ontario Hydro Summary Statement -Select Committee on Hydro Affairs Reactor Safety Hearings, October 2, 1979.	October 2, 1979
E-110	Scintillating Staff Summary on Safety of Ontario's Nuclear Reactors.	October 3, 1979
E-111	The Need for Electrical Capacity -Review and update of material presented to Committee January to March, 1979 -Select Committee on Ontario Hydro Affairs, October 1979. Now listed as D-105	October 24, 1979

Exhibit #	Title	Date Tabled
E-111-A	Notes on the Kemeny Report - President's Commission on Three Mile Island.	November 15, 1979
E-112	Rough Draft Report - Select Committee on Ontario Hydro Affairs on its Examination of the Safety of Ontario's Nuclear Reactors, prepared by Alan Schwartz, Counsel and James Fisher, Consultant.	November 15, 1979
E-113	Letter dated November 5, 1979 from M.P. Martin, Media Relations Coordinator, Atomic Energy Canada Ltd., to Alan M. Schwartz, Committee Counsel, Select Committee on Ontario Hydro Affairs Re: documentation concerning; "copies of all correspondence between AECL-AECB —Ontario Hydro with respect to NSFF/LOCA/ECC Studies and Reports relating to design power ratings for the Douglas Point and Rolphton reactors".	November 15, 1979
E-114	Letter dated November 7, 1979 from Canadian Coalition for Nuclear Responsibility to Donald C. MacDonald, Chairman, Select Committee on Ontario Hydro Affairs Re: "Cases of Misinformation and Attempted Suppression by Canadian Nuclear Institutions and Representatives."	November 15, 1979
E-115	Letter to Donald C. MacDonald, Chairman from Norman Rubin, Nuclear Power Researcher outlining two statements regarding IOWG in the Rough Draft Report (E-112) which Mr. Rubin contends are wrong. The two points underlined in the letter are: 1. "Release limits are set for the most improbable accidents (our category 3 above)." and, 2. Release limits for normal operation and for accidents that correspond to the reference single and dual accidents are lowered.	November 20, 1979

Exhibit #	Title	Date Tabled
E-116	Letter to Mr. L.W. Woodhead, Director of the Nuclear Generation Division of Ontario Hydro, from Mr. T.J. Molloy, Manager, Power Reactor Operational Division of the Atomic Energy Control Board (Ottawa); which outlines their approval of Ontario Hydro improving the availability of safety systems at the operating nuclear stations.	November 20, 1979
E-117	Carbon 14 Candu - PHW Generating Stations T.R. Clarke Radioactivity Management and Environmental Protection Department. October 1979.	January 8, 1980
E-118	Carbon 14 Control A Presentation to Staff of the Atomic Energy Control Board, November 19, 1979. G.A. Vivian, Nuclear Materials Management Department, Design, and Development Division, Ontario Hydro.	January 8, 1980
E-119	Health Physics Aspects of Carbon-14 Dr. K. Y. Wong. Safety Services Department, Health and Safety Division, Ontario Hydro. November 1979.	January 8, 1980
E-120	Letter to Mr. S. Conway, M.P.P. from Jacques Rubacha, Petawawa, Ontario regarding the NPD reactor.	January 29, 1980
E-121	Letter from The Public Interest Advocacy Centre dated February 8, 1980 concerning the NPD generating station and defining the Public Interest Advocacy Centre's position. (Tabled originally as F-55)	February 12, 1980
E-122	Presentation by Ontario Hydro to the Select Committee on Ontario Hydro Affairs on deposits of NPD NGS boiler tubes by Ontario Hydro, dated February 12, 1980. (Tabled originally as F-56)	February 12, 1980

Exhibit #	Title	Date Tabled
E-123	Presentation to The Select Committee of the Ontario Legislature on NPD Injection Water System and Containment System Modifications by Ontario Hydro/AECL February 1980. (Tabled originally as F-57)	February 12, 1980
E-124	Douglas Point Station Data. (Tabled originally as F-58).	February 13, 1980
E-125	Presentation to the Select Committee on Ontario Hydro Affairs by Atomic Energy of Canada Limited entitled "Emergency Coolant Injection System at Douglas Point (A review of the background to the correspondence between AECL-AECB-Ontario Hydro)" presented February 13, 1980. (Tabled originally as F-59).	February 13, 1980
E-126	Letter addressed to Mr. J. Fisher from J.E. Wilson of Ontario Hydro, the enclosure of which is a copy of a chronology of correspondence between T.G. Molloy (AECB) and L.W. Woodhead (Ontario Hydro). (Tabled originally as F-61).	February 14, 1980
E-127	Ontario Hydro response to letter from Mr. R. Torrie to the Select Committee dated August 16, 1979 regarding Pickering NGS "A" ECCS. Unavailability. (Tabled originally as F-62).	February 14, 1980
E-128	"Environmental Effects: Scenarios of C-14 Releases from the World Nuclear Power Industry from 1975 to 2020 and the Estimated Radiological Impact", from the September-October, 1978 edition of Nuclear Safety. (Tabled originally as F-63).	February 19, 1980
E-129	"Nuclear Power Stations as Sources of Carbon-14 Discharge", translation from a Russian article from the Institute of Biophysics of the Ministry of Health of the USSR in Moscow by V.P. Rublevsky, A.D. Zykova and A.D. Turkin. (Tabled originally as F-64)	February 19, 1980

Exhibit #	Title	Date Tabled
E-130	Presentation by Mr. Kelly to the Select Committee of the Ontario Legislature on AECB/Ontario Hydro correspondence regarding Safety System Availability at Operating Stations, dated February 1980.	February 20, 1980
E-131	Letter to Mr. Domaratzki dated November 7, 1979 and signed by D.A. Watson, Manager of Safety Services Department, Ontario Hydro regarding Carbon 14.	February 20, 1980
E-131-A	Information Summary on Carbon 14 Studies at Ontario Hydro.	February 20, 1980
E-131-B	Carbon 14 Control A Presentation to Staff of the Atomic Energy Control Board, November 19, 1979. G.A. Vivian, Nuclear Materials Management Department Design, Development Division. Ontario Hydro. (Also tabled as E-118)	February 20, 1980
E-131-C	Health Physics Aspects of Carbon 14 Dr. K.Y. Wong Safety Services Department Health and Safety Division Ontario Hydro November 1979 (Also tabled as E-119)	February 20, 1980
E-131-D	Carbon 14 Candu - PHW Generating Stations T.R. Clarke Radioactivity Management and Environmental Protection Department, October 1979. (Also tabled as E-117)	February 20, 1980
E-132	Information Summary on Carbon 14 Studies at Ontario Hydro. (Also tabled as E-131-A)	February 20, 1980

Exhibit #	Title	Date Tabled
E-133	Bruce 'A' Boilers, presentation on February 21, 1980 to The Select Committee on Ontario Hydro Affairs prepared by R.J. Atchison, Director of Assessment Branch and B. Jarman, Assoc. Scientific Advisor, both of Atomic Energy Control Board.	February 21, 1980
E-134	Memorandum from W.R. Bush to R.J. Atchison, entitled, 'Carbon 14 Information for Select Committee', dated February 18, 1980.	February 21, 1980
E-135	Document entitled "Transportation Incidents Involving Canadian Shipments of Radioactive Material, 1947 to 1978", by J.M. Jardine.	February 21, 1980
E-136	Document entitled "Atomic Energy Control Board Radioactive Material Transport", by Michael C. White, dated October 1, 1979.	February 21, 1980
E-137	Presentation to Select Committee of the Ontario Legislature on Ontario Hydro. Engineering Studies for Carbon 14 Control, February 26, 1980.	February 26, 1980
E-138	Presentation to the Select Committee of the Ontario Legislature on Carbon 14. Production and Releases from Ontario Hydro Reactors, dated February 16, 1980.	February 26, 1980
E-138-A	Carbon 14 Distribution after Injection into the Tropospere.	February 26, 1980
E-138-B	Four Compartment Models for Distribution of Carbon 14.	February 26, 1980
E-139	Document entitled Transportation of radioactive materials.	February 26, 1980
E-140	A list of people on the panel. On the letterhead of the CNA, Canadian Nuclear Association Delegation to the Ontario Select Committee, dated February 27, 1980.	February 27, 1980

Exhibit #	Title	Date Tabled
E-140-A	Document on the Canadian Nuclear Association letterhead, entitled "Introductory Remarks to Ontario Select Committee Hearing, dated February 27, 1980", by William MacOwan, Chairman of the CNA.	February 27, 1980
E-140-B	Hard-cover series of the slides which were seen later in the morning. The first page has a slide entitled Electrical Energy in Ontario - - Ontario Imports Approximately 80 Per Cent of Its Energy Requirements, Mostly as Fossil Fuels.	February 27, 1980
E-141	A letter dated February 29, 1980 and addressed to, Jim Fisher, Consultant to the Select Committee on Ontario Hydro Affairs from J.E. Wilson, Manager, Public Hearings Department, Ontario Hydro with attachments including a Memorandum to Mr. G.R. Childerhose, Manager, RMEP the subject of which is entitled NPD NGS -IJW Valve Cycling, dated February 27, 1980.	March 13, 1980
E-142	A letter dated March 12, 1980 and addressed to, Jim Fisher, Consultant to the Select Committee on Ontario Hydro Affairs from J.E. Wilson, Manager, Public Hearings Department, Ontario Hydro the letter is entitled "Additional Information on Carbon 14" documents attached to the letter are entitled: 1. "The Carbon Content of Food Crops and Consideration of the Biological Effects of the Transmutation on Carbon 14 and Tritium" - written by D.K. Myers of the Chalk River lab. 2. "Radionuclide metabolism and dosimetry".	March 13, 1980

Exhibit #	Title	Date Tabled
E-143	Comments from Dr. Gordon Edwards dated March 19, 1980 entitled "Ontario Legislature Investigates Nuclear Safety". A response to the Select Committee on Ontario Hydro Affairs' Interim Report entitled "The Safety of Ontario's Nuclear Reactors"'.	April 10, 1980
E-144	Comments by the Atomic Energy Control Board Staff on the December, 1979, Interim Report of the Ontario Select Committee on Ontario Hydro Affairs on "The Safety of Ontario's Nuclear Reactors", received under covering letter from R.W. Blackburn, Secretary to The Atomic Energy Control Board dated February 27, 1980 and directed to Mr. Donald C. MacDonald, Chairman, Select Committee on Ontario Hydro Affairs.	April 10, 1980
E-145	Letter addressed to Mr. J.D. Fisher, Canada Consulting Group on April 8, 1980, from Mr. J.E. Wilson, Manager, Public Hearings, Ontario Hydro, the subject of which is headlined as "Airborne Radionuclides". Three attachments to this letter are entitled: 1) Table 1: Airborne Releases from Pickering NGS-1978. 2) Table 2: Typical Ranges of Noble Gas Composition Measured in Pickering NGS Stack Effluent. 3) Table 3: Airborne Radionuclides	April 10, 1980
E-146	Staff Summary for Select Committee on Ontario Hydro Affairs entitled "Reaching Final Conclusions on the Safety of Ontario's Nuclear Reactors" dated April 10, 1980.	April 10, 1980

APPENDIX E

INFORMATION PROVIDED BY ONTARIO HYDRO TO THE LEGISLATIVE LIBRARY FOR THE PURPOSES OF, AND USE BY, THE PUBLIC AND THE SELECT COMMITTEE ON ONTARIO HYDRO AFFAIRS (436 Volumes)

APPENDIX E
INFORMATION PROVIDED BY ONTARIO HYDRO
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THE SELECT COMITTEE ON ONTARIO HYDRO AFFAIRS

(436 Volumes)

UNRESTRICTED ACCESS

Documents provided to Select Committee members, staff, Party research offices and the Hydro Public Reference Centre, Friday June 8 and Monday June 11, 1979.

Vol. 1 — Applications to Operate (Bruce Unit 4, Pickering Unit 1, Douglas Point and NPD). Operating Licences (Bruce, Pickering, Douglas Point and NPD). Bruce "A" Operating Policies and Principles.

Vol. 2 — Sample of Significant Abnormal Event Reports.

Vol. 3 — 4th Quarter 1978 Quarterly Technical Reports (Bruce, Pickering and Douglas Point) and the 1978 Annual Report for NPD.

Documents provided to the Select Committee office and to the Hydro Public Reference Centre Wednesday, June 13, 1979.

Vol. 4 — Bruce N.G.S. "A" Application to Operate Units 1 to 4.

Vol. 5 — Pickering N.G.S. "A" Application to Operate, Units 1 to 4.

Vol. 6 — Douglas Point N.G.S. Application to Operate.

Vol. 7 — NPD G.S. Application to Operate.

Vol. 8 — Bruce N.G.S. "A" Application Policies and Principles and Radiation Protection Procedures.

Vol. 9 — Pickering N.G.S. "A" Operating Policies and Procedures.

Vol. 10 — Douglas Point N.G.S. Operating Policies and Principles and Radiation Protection Procedures.

Vol. 11 — NPD G.S. Operating Policies and Principles and Radiation Protection Procedures.

Vol. 12 — Bruce N.G.S. "A" Quarterly Technical Reports 3rd Qtr. 1976 to 4th Qtr. 1977.

Vol. 13	Bruce N.G.S. "A" Quarterly Technical Reports 1st Qtr. 1978 to 4th Qtr. 1978.
Vol. 14	Pickering N.G.S. "A" Quarterly Technical Reports 1971 to 4th Qtr. 1973.
Vol. 15	Pickering N.G.S. "A" Quarterly Technical Reports 1st Qtr. 1974 to 4th Qtr. 1975.
Vol. 16	Pickering N.G.S. "A" Quarterly Technical Reports 1st Qtr. 1976 to 4th Qtr. 1977.
Vol. 17	Pickering N.G.S. "A" Quarterly Technical Reports 1st Qtr. 1978 to 4th Qtr. 1978.
Vol. 18	Douglas Point N.G.S. "A" Annual Technical Reports 1969 to 1973.
Vol. 19	Douglas Point N.G.S. 1974 Quarterly Technical Reports.
Vol. 20	Douglas Point N.G.S. 1975 Quarterly Technical Reports.
Vol. 21	Douglas Point N.G.S. 1976 Quarterly Technical Reports.
Vol. 22	Douglas Point N.G.S. 1977 Quarterly Technical Reports.
Vol. 23	Douglas Point N.G.S. 1978 Quarterly Technical Reports.
Vol. 24	NPD G.S. Annual Reports 1962-1969.
Vol. 25	NPD G.S. Annual Reports 1970-1978.
Vol. 26	Bruce Abnormal Events Reports to the AECB
Vol. 27	Design and Development Report List. Health Physics Report List. Nuclear Generation Division Index Vol. 1.
Vol. 28	Nuclear Generation Division Index Vol. 2. Nuclear Generation Division Index Vol. 3.

Documents provided to the Select Committee office and to the Hydro Public Reference Centre on June 18, 1979.

Vol. 29	Health Physics Investigation Reports of Excess Doses.
Vol. 29A	Sample of Lifetime Occupational Dose Report records.

Documents provided June 28, 1979 to the Legislative Library and to the Hydro Public Reference Centre.

Vol. 30	Douglas Point N.G.S. Monthly Technical Reports 1963 and 1964.
Vol. 31	Douglas Point N.G.S. Monthly Technical Reports 1965 and 1966.
Vol. 32	Douglas Point N.G.S. Monthly Technical Reports 1967 and 1968.
Vol. 33	Douglas Point N.G.S. Monthly Technical Reports 1969.
Vol. 34	Douglas Point N.G.S. Monthly Technical Reports 1970.
Vol. 35	Douglas Point N.G.S. Monthly Technical Reports 1971.
Vol. 36	Douglas Point N.G.S. Monthly Technical Reports 1972.
Vol. 37	Douglas Point N.G.S. Monthly Technical Reports 1973 to 1979.
Vol. 38	NPD G.S. Monthly Technical Reports 1960.
Vol. 39	NPD G.S. Monthly Technical Reports 1961. (January to June)
Vol. 40	NPD G.S. Monthly Technical Reports 1961. (July to December)
Vol. 41	NPD G.S. Monthly Technical Reports 1962.
Vol. 42	NPD G.S. Monthly Technical Reports 1963 and 1964.
Vol. 43	NPD G.S. Monthly Technical Reports 1965 and 1966.
Vol. 44	NPD G.S. Monthly Technical Reports 1967 and 1968.
Vol. 45	NPD G.S. Monthly Technical Reports 1969.
Vol. 46	NPD G.S. Monthly Technical Reports 1970 and 1971.
Vol. 47	NPD G.S. Monthly Technical Reports 1972 to 1979.
Vol. 48	Bruce N.G.S. "A". 1974 SER 1 to 12. 1975 SER 1 to 27.
Vol. 49	Bruce N.G.S. "A". 1976 SER 1 to 56.
Vol. 50	Bruce N.G.S. "A". 1977 SER 1 to 30.

Vol. 51	Bruce N.G.S. "A". 1977 SER 31 to 55.
Vol. 52	Bruce N.G.S. "A". 1977 SER 56 to 94.
Vol. 53	Bruce N.G.S. "A". 1978 SER 1 to 50.
Vol. 54	Bruce N.G.S. "A". 1978 SER 51 to 99.
Vol. 55	Bruce N.G.S. "A". 1979 SER 1 to 54.
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Vol. C-110	Douglas Point N.G.S. Design Manual 63520.2 to 63812.2
Vol. C-111	Douglas Point N.G.S. Design Manual 64210 to 67921
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Vol. C-118	Bruce N.G.S. "A" Operating Manual 00000 to 09053
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Vol. C-163	Bruce N.G.S. "A" Periodic Inspection Program
Vol. C-164	Pickering N.G.S. "A" Periodic Inspection Program
Vol. C-165	Douglas Point N.G.S. Periodic Inspection Program
Vol. C-166	NPD G.S. Periodic Inspection Program

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Vol. C-187	Pickering N.G.S. "A" Commissioning Reports - Unit 4 06070.1(A) to 7711.2(A)
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Vol. C-192	Douglas Point N.G.S. Commissioning Reports 5200.1(A1) to 5131.3

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Vol. C-195	Douglas Point N.G.S. Commissioning Reports 6313.1(A1) to 7171.1
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Vol. C-197	NPD G.S. Commissioning Reports 100.1(A1) to 331.8(C1)
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Vol. C-202	NPD G.S. Commissioning Reports 733.1 to 787.2(A1)
Vol. C-203	Bruce N.G.S. "A" System Training Manual
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Vol. C-216	NPD G.S. System Training Manual
Vol. C-217	NPD G.S. System Training Manual

Reports Requested By The Select Committee - Controlled Access

Vol. No.	Report Number	Title
C-218	78151	A Safety-Reliability Assessment of Emergency Power Supply (EPS) System, Bruce GS B
	74075	Aircraft Strikes at Bruce
	74440	Aircraft Strikes at Bruce GS
	74074	Aircraft Strikes at Pickering GS B
	74281	Aircraft Strikes at Pickering GS
	74320	Boiler Feedwater System Reliability of Bruce B GS

C-219	78227	Bruce GS A Probability of a Cl IV Power Failure Following a Loss of Coolant Accident
	79004	Bruce GS B Safety-Reliability Assessment of Emergency Power Supply (EPS) System
	74305	Control Centre Complex Large Object Penetration
	78330	Pickering GS B Consequences After a Loss-of-Coolant Accident with Vacuum, Dousing or Pressure Relief Valves Unavailable
	79107	Pickering GS B Power Transient Following Loss of Coolant with only one Shutdown System Assumed Available
	78213	Pickering GS B Secondary Side Loss of Coolant Analysis
	75275	Pipe Ruptures in Primary Heat Transport System Distribution List Bruce GS
	76265	Postulated Loss of Collant Accidents in NA44 Airlock Impairment Assessment
	76263	Postulated Loss of Coolant plus Loss of Dousing Accidents Assessment NA44
	76264	Postulated Loss of Coolant plus Loss of Vacuum Accidents Assessment NA44
C-220	77201	Primary Heat Transport System IQC Reliability of Pickering B GS
	75162	Turbine Generators Fires - Nuclear Safety Aspects
	74055	Turbogenerator Missiles at Pickering GS
	76044	Turbogenerator Missiles at Bruce GS Supplement
	CNS-IR-211-2	Review of the Pickering GS Containment System Under Accident Conditions
	CNS-IR-411-3	Reliability Analysis of the Turbine Generator Overspeed Protection System at NPD NGS
	RMEP-IR-015-6	Pickering NGS A Long Term Post-Loca Releases
	RMEP-IR-015-8	Long Term Releases of Fission Products from Containment at Bruce NGS A folowing postulated Loss of Coolant Accidents

APPENDIX F

CORRESPONDENCE BETWEEN AECL-AECB-ONTARIO HYDRO SUBMITTED TO THE LEGISLATIVE LIBRARY FOR THE PURPOSES OF, AND USE BY, THE PUBLIC AND THE SELECT COMMITTEE ON ONTARIO HYDRO AFFAIRS

APPENDIX F

CORRESPONDENCE BETWEEN AECL - AECB - ONTARIO HYDRO

SUBMITTED TO THE LEGISLATIVE LIBRARY

FOR THE PURPOSES OF, AND USE BY,

THE PUBLIC AND

THE SELECT COMMITTEE ON ONTARIO HYDRO AFFAIRS

Volume AECL-1	Correspondence between AECL - AECB - Ontario Hydro relating to no significant fuel failures, loss of coolant accidents and emergency core cooling at Nuclear Power Demonstration Generating Station from July 13, 1976.
Volume AECL-2	Douglas Point correspondence between July 16th, 1976 and April 7th, 1978.
Volume AECL-3	Douglas Point correspondence between April 13th, 1978 and January 16th, 1979.
Volume AECL-4	Douglas Point correspondence between January 16th, 1979 and September 25th, 1979.

APPENDIX G

LIST OF RECOMMENDATIONS

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LIST OF RECOMMENDATIONS

RECOMMENDATION I	ONTARIO HYDRO SHOULD CONTINUE TO PROVIDE PUBLIC ACCESS TO ALL OF THE INFORMATION MADE AVAILABLE TO THE COMMITTEE BY KEEPING THE REPORTS NOW AVAILABLE IN THE LEGISLATIVE LIBRARY REGULARLY UPDATED AND CURRENT.
RECOMMENDATION II	ONTARIO HYDRO SHOULD IMMEDIATELY ADVISE THE LEGISLATIVE ASSEMBLY, THROUGH THE MINISTER OF ENERGY, OF ANY DECISION, OCCURRENCE OR DESIGN REANALYSIS WHICH MIGHT BE OF PARTICULAR INTEREST OR CONCERN TO THE PUBLIC.
RECOMMENDATION III	A COUNCIL SHOULD BE FORMED BY THE GOVERNMENT OF ONTARIO WITH GIVEN TERMS OF REFERENCE AND REPRESENTATION FROM WITHIN AND OUTSIDE THE NUCLEAR ESTABLISHMENT TO PROVIDE AN INSTITUTIONAL FORUM FOR PUBLIC PARTICIPATION AND A FOCUS FOR CONCERNS ABOUT RADIATION PROBLEMS IN ONTARIO, TO BUILD UP ONTARIO-BASED TECHNICAL KNOWLEDGE AND TO OVERSEE AS MUCH EPIDEMIOLOGICAL WORK AS IS NECESSARY TO DECIDE WHAT THE STANDARDS SHOULD BE FOR THE HEALTH AND SAFETY OF PEOPLE IN ONTARIO. THE COUNCIL SHOULD REVIEW PARTICULAR PROBLEMS OF RADIATION ASSOCIATED WITH OPERATING OR PLANNED REACTORS, INDEPENDENT OF ONTARIO HYDRO AND THE GOVERNMENT. THE COUNCIL SHOULD WORK TOWARD THE ESTABLISHMENT OF A FEDERAL-PROVINCIAL WORKING GROUP TO CO-ORDINATE THE NATIONAL STANDARDS WITH THE WORK AND FINDINGS OF THE PROVINCIAL GROUP. THE POWERS OF THE COUNCIL SHOULD BE THAT OF MAKING INDEPENDENT AND PUBLIC RECOMMENDATIONS TO AN APPROPRIATE MINISTER.
RECOMMENDATION IV	ONE OF THE FIRST TASKS THE COUNCIL SHOULD TAKE ON AND GIVE HIGH PRIORITY TO IS AN INDEPENDENT REVIEW OF THE ADEQUACY OF CURRENT PROPOSED RELEASE LIMITS FOR CARBON-14 AND TRITIUM, TAKING INTO ACCOUNT BOTH LOCAL AND GLOBAL CONCERNS.

RECOMMENDATION V

ONTARIO HYDRO SHOULD ENSURE THAT THE NUCLEAR INTEGRITY REVIEW PANEL REPORTS ANNUALLY ON ITS ACTIVITIES TO IMPROVE THE RELIABILITY, EFFECTIVENESS AND INDEPENDENCE OF NUCLEAR SYSTEMS, HIGHLIGHTING CONCLUSIONS OF COMPLETED PROJECTS AND PROBLEMS UNDER ACTIVE STUDY. SUCH A REPORT SHOULD BE MADE AVAILABLE TO THE PUBLIC FROM ONTARIO HYDRO AND AT ALL INFORMATION CENTRES AND SHOULD BE TABLED IN THE LEGISLATIVE ASSEMBLY BY THE MINISTER RESPONSIBLE FOR ONTARIO HYDRO.

RECOMMENDATION VI

THE AECB IN ITS ANNUAL REPORT SHOULD REVIEW AND COMMENT ON REPORTED UNAVAILABILITY OF SYSTEMS IN NUCLEAR POWER PLANTS AND SHOULD SUMMARIZE THE ACTIVITIES OF ITS COMPLIANCE BRANCH.

RECOMMENDATION VII

HYDRO SHOULD UNDERTAKE A COMPREHENSIVE REVIEW OF PROCESSES FOR DEALING WITH HUMAN RESOURCES TO IMPROVE THE ORGANIZATIONAL CLIMATE AND THE FUNCTIONING OF THOSE PARTS OF THE ORGANIZATION THAT DEAL WITH THE SPECIAL PROBLEMS OF NUCLEAR POWER.

RECOMMENDATION VIII

HYDRO SHOULD TIGHTEN ITS SYSTEM FOR MANAGING THE FOLLOW-UP TO SIGNIFICANT EVENTS IN ORDER TO ENSURE THAT APPROPRIATE REMEDIAL ACTION RESULTS, THAT EVENTS ARE CLASSIFIED BY TYPE AND/OR COMPONENT AND THAT EVENTS ARE CROSS-REFERENCED TO OTHER PLANTS IN A MANNER WHICH CAN BE TRACED THROUGH THE REPORTING SYSTEM.

RECOMMENDATION IX

ONTARIO HYDRO SHOULD ENSURE THAT A COMPLETE ENGINEERING REVIEW OF THE NPD STATION IN ITS MODIFIED STATE IS UNDERTAKEN AS A BASIS FOR A NEW FINAL HAZARDS REPORT THAT REFLECTS BOTH THE PLANT MODIFICATIONS AND THE MOST CURRENT RESEARCH INFORMATION. AFTER AECB REVIEW AND APPROVAL THE REPORT SHOULD BE PRINTED WITHIN TWELVE MONTHS AS A NEW SAFETY REPORT AVAILABLE FOR PUBLIC SCRUTINY.

RECOMMENDATION X	THE AECB SHOULD COMMISSION A STUDY TO ANALYZE THE LIKELIHOOD AND CONSEQUENCES OF A CATASTROPHIC ACCIDENT IN A CANDU REACTOR. THE STUDY SHOULD BE DIRECTED BY RECOGNIZED EXPERTS OUTSIDE THE AECB, AECL AND ONTARIO HYDRO. IT SHOULD BE FUNDED BY A SPECIAL GRANT FROM THE FEDERAL GOVERNMENT. IF THIS STUDY IS NOT COMMISSIONED BY JULY 31, 1980, THE PROVINCE OF ONTARIO SHOULD ENSURE THAT IT IS UNDERTAKEN.
RECOMMENDATION XI	THE AECB SHOULD MAKE SIGNIFICANTLY MORE SPECIFIC ITS OWN CURRENT CRITERIA FOR BOTH SINGLE AND DUAL FAILURE ACCIDENTS AS WELL AS FOR MINIMIZING THE PROBABILITY OF A CATASTROPHIC ACCIDENT, INCORPORATING WHERE APPROPRIATE, THE TIGHTENING IMPLICIT IN THE REPORT OF THE INTER-ORGANIZATIONAL WORKING GROUP (IOWG).
RECOMMENDATION XII	THE GOVERNMENT OF ONTARIO SHOULD PUBLICLY URGE THE FEDERAL GOVERNMENT TO ENSURE THAT THE AECB IS ADEQUATELY FUNDED, PARTICULARLY IN LIGHT OF THE SIGNIFICANCE OF ITS CURRENT AND ONGOING WORK AND THE PUBLIC TRUST IT MUST FULFILL.
RECOMMENDATION XIII	THE AECB SHOULD SET OUT A SPECIFIC TIMETABLE FOR THE RECEIPT AND APPROVAL OF DOCUMENTS AT EACH STEP IN THE LICENSING PROCESS.
RECOMMENDATION XIV	THE AECB SHOULD DEFINE AS CLEARLY AS POSSIBLE THE KEY PHRASES, SUCH AS "REQUEST" OR "ORDER" THAT FORM PART OF THE ON-GOING COMMUNICATION WITH THE LICENSEE AND SHOULD TELL THE LICENSEE EXACTLY WHAT AUTHORITIES HAVE BEEN GRANTED TO STAFF MEMBERS.
RECOMMENDATION XV	THE AECB SHOULD, AS A MATTER OF ROUTINE, BRING DEBATES WITH A LICENSEE TO A FIRM CONCLUSION BY INDICATING, AT THE APPROPRIATE TIME, THE BOARD'S DECISION AND THE REASONS THEREFORE. WHERE THE BOARD IS NOT YET IN A POSITION TO MAKE A DECISION IT SHOULD PLACE AN APPROPRIATE TIME CONSTRAINT ON THE DURATION OF UNRESOLVED DISAGREEMENTS RELATING TO VITAL SAFETY MATTERS.

RECOMMENDATION XVI

THE BOARD SHOULD SET OUT THE FUNDAMENTAL REQUIREMENTS FOR THE CRITICAL SYSTEMS IN A NUCLEAR PLANT -- PROCESS SYSTEMS, EMERGENCY COOLING SYSTEMS AND CONTAINMENT SYSTEMS --AND THE WAYS IN WHICH ACCIDENT ANALYSIS MUST BE DONE TO SATISFY THE REQUIREMENTS.

RECOMMENDATION XVII

THE BOARD SHOULD SPECIFY THE ROUTINE REQUIREMENTS OF ITS OWN ON-SITE INSPECTORS, DEVELOP APPROPRIATE DAY-TO-DAY OPERATIONAL AUDITING ROUTINES AND BEGIN A REGULAR SYSTEM OF INSPECTION REPORTS.

RECOMMENDATION XVIII

THE AECB SHOULD STRIVE TO ADOPT THE MOST OPEN AND PUBLIC POSITION POSSIBLE BY BROADLY INTERPRETING ITS CURRENT LEGISLATION.

RECOMMENDATION XIX

THE AECB SHOULD BROADEN ITS MEMBERSHIP TO INCLUDE REPRESENTATION FROM THE GENERAL PUBLIC AS WELL AS THE INFORMED TECHNICAL COMMUNITY.

RECOMMENDATION XX

THE AECB SHOULD SEEK AN INCREASE IN ITS FUNDING TO ENABLE IT TO INCREASE ITS CONTRACTING FOR INDEPENDENT OUTSIDE RESEARCH INTO MATTERS OF NUCLEAR SAFETY.

RECOMMENDATION XXI

THE AECB SHOULD REPORT TO THE HOUSE OF COMMONS THROUGH A MINISTER OTHER THAN THE MINISTER RESPONSIBLE FOR AECL.

RECOMMENDATION XXII

THE AECB SHOULD MAKE ITS PROCEEDINGS OF DECISION MORE WIDELY KNOWN. ITS MEETINGS SHOULD BE OPEN TO THE PUBLIC UNLESS THERE IS A REASON FOR KEEPING ONE CLOSED.

RECOMMENDATION XXIII

THE AECB SHOULD WORK WITH ITS LICENSEES TO ENSURE THAT DOCUMENTS MADE AVAILABLE TO THE PUBLIC ARE, TO THE GREATEST EXTENT POSSIBLE, ACCURATE, COMPLETE AND COMPREHENSIBLE.

RECOMMENDATION XXIV

THE RULES UNDER WHICH THE BOARD OPERATES, INCLUDING SPECIFIC LICENSING CRITERIA, SHOULD BE THE SUBJECT OF PUBLIC HEARINGS WHEN FORMULATED OR CHANGED. THE AECB SHOULD HAVE GENERAL POWERS OF INTERPRETATION AND THE POWER TO GRANT EXEMPTIONS. INTERPRETATIONS AND EXEMPTIONS MUST, HOWEVER, BE PUBLICLY EXPLAINED IN A TIMELY MANNER IN THE BOARD'S REASONS FOR A PARTICULAR DECISION.

RECOMMENDATION XXIV	[illegible] SHOULD SET OUT THE REQUIREMENTS FOR THE [illegible]S IN A NUCLEAR PLANT — [illegible]EMS, EMERGENCY COOLING [illegible] CONTAINMENT SYSTEMS — AND [illegible] WHICH ACCIDENT ANALYSIS [illegible] DONE TO SATISFY THE [illegible]
[illegible]	[illegible] SHOULD SPECIFY THE ROUTINE REQUIREMENTS OF ITS OWN ON-SITE INSPECTORS, DEVELOP APPROPRIATE DAY-TO-DAY OPERATIONAL AUDITING ROUTINES AND BEGIN A REGULAR SYSTEM OF INSPECTION REPORTS.
RECOMMENDATION XVIII	THE AECB SHOULD STRIVE TO ADOPT THE MOST OPEN AND PUBLIC POSITION POSSIBLE BY BROADLY INTERPRETING ITS CURRENT LEGISLATION.
RECOMMENDATION XIX	THE AECB SHOULD BROADEN ITS MEMBERSHIP TO INCLUDE REPRESENTATION FROM THE GENERAL PUBLIC AS WELL AS THE INFORMED TECHNICAL COMMUNITY.
RECOMMENDATION XX	THE AECB SHOULD SEEK AN INCREASE IN ITS FUNDING TO ENABLE IT TO INCREASE ITS CONTRACTING FOR INDEPENDENT OUTSIDE RESEARCH INTO MATTERS OF NUCLEAR SAFETY.
RECOMMENDATION XXI	THE AECB SHOULD REPORT TO THE HOUSE OF COMMONS THROUGH A MINISTER OTHER THAN THE MINISTER RESPONSIBLE FOR AECL.
RECOMMENDATION XXII	THE AECB SHOULD MAKE ITS PROCEEDINGS OF DECISION MORE WIDELY KNOWN. ITS MEETINGS SHOULD BE OPEN TO THE PUBLIC UNLESS THERE IS A REASON FOR KEEPING ONE CLOSED.
RECOMMENDATION XXIII	THE AECB SHOULD WORK WITH ITS LICENSEES TO ENSURE THAT DOCUMENTS MADE AVAILABLE TO THE PUBLIC ARE, TO THE GREATEST EXTENT POSSIBLE, ACCURATE, COMPLETE AND COMPREHENSIBLE.